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INTEGRATED CORRIDOR MANAGEMENT – DES MOINES METRO AREA

PHASE 1 STRATEGIES

Des Moines Metropolitan Area Integrated Corridor Management (ICM)

June 24, 2019

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Executive Summary

In 2016, the Iowa Department of Transportation (Iowa DOT) published its Transportation System Management and Operations (TSMO) Strategic Plan. This plan laid out a vision for TSMO that is oriented toward making Iowa's transportation system safe, efficient, and reliable while supporting the state's environmental and economic health. In support of Iowa DOT's broader TSMO vision and as a response to increasing congestion trends, the Iowa DOT and local partners are pursuing integrated corridor management (ICM) in the Des Moines Metropolitan Area as a way to proactively manage traffic along interstate and arterial corridors.

ICM is an operational approach for multi-modal, multi-jurisdictional coordination aimed at delivering a safer, more reliable, and more convenient transportation system for all users and in a more cost-effective manner compared to traditional capacity expansion projects. The ICM approach is based on a combination of strategies that are used to proactively manage and operate the regional transportation system within a defined corridor or set of connected corridors as an integrated system rather than as individual transportation networks.

In October 2018 the Iowa DOT began an initiative to identify and prioritize ICM strategies that may successfully address safety, mobility, and efficiency of the Des Moines Metropolitan transportation network to investigate how ICM may benefit the Des Moines Metropolitan region. This Phase 1 Strategies Report documents the ICM project identification process, focusing on the activities leading up to the identification of highly desired strategies that align with broader agency goals, address local needs, and maximize local transportation investments.

As a result of the ICM project identification process, 16 strategies were selected for implementation. Depending on the level of sophistication of each higher priority strategy, the Iowa DOT slotted each strategy for a future course of development, including development of a Concept of Operations (strategies needing additional understanding or how agencies will operate it), Implementation Plan (strategies where operations are known and can proceed directly to implementation), or Needs Additional Development (strategies where additional data and analysis may be required to determine how the strategy will be implemented).

The following strategies will be the subject of Concept of Operations documents:

- Median Barrier Gates
- Add US 65 / Iowa 5 Bypass Travel Time Comparison to Truck Information System
- Investigate Signal Optimization

These six strategies will be the focus of implementation plans:

- Naming Conventions for System Ramps
- Permit Over-Sized Trucks for Off-Peak Only
- Queue Spillback Mitigation
- Median Barrier Gates
- Add US 65 / Iowa 5 Bypass Travel Time Comparison to Truck Information System
- Investigate Signal Optimization

These five strategies are planned for concept refinement:

- Dynamic Shoulder Lanes/Part-time Shoulder Use
- Variable Speed Advisories
- Extend Acceleration/Deceleration Lanes
- Add Exit Option Lanes
- Ramp Metering/Adaptive Ramp Metering

It is anticipated that additional implementation plans will be developed subsequent to the findings of this report. The following five strategies represent anticipated future implementation plans:

- Investigate Recurring Signal Optimization Program/Dedicated Funding
- Add US 65/Iowa 5 Bypass to Travel Time Comparison in DMS Messaging
- Build Traffic Signal Inventory Data Portal for Metro Area with Improvement Screening
- Update Communications/Fiber Inventory

All plans developed in Phase 1 are expected to be complete by late 2019.

1 Introduction

In 2016, the Iowa Department of Transportation (Iowa DOT) published its Transportation System Management and Operations (TSMO) Strategic Plan. This plan laid out a vision for TSMO that is oriented toward making Iowa's transportation system safe, efficient, and reliable while supporting the state's environmental and economic health. To provide a specific direction for the TSMO Program, the Iowa DOT defined six strategic goals and subsequently developed corresponding objectives to support each. These goals and objectives, which are identified below, define the priorities for integrating TSMO throughput Iowa in support of the Iowa DOT's vision of smarter, simpler, and customer driven.

- **Safety** – Reduce crash frequency and severity
- **Reliability** – Improve transportation system reliability, increase system resiliency, and add highway capacity in critical corridors
- **Efficiency** – Minimize traffic delay and maximize transportation system efficiency to keep traffic moving
- **Convenience** – Provide ease of access and mobility choices to customers
- **Coordination** – Engage all Iowa DOT disciplines, and external agencies and jurisdictions to proactively manage and operate the transportation system
- **Integration** – Incorporate TSMO strategies throughout Iowa DOT's transportation planning, design, construction, maintenance and operations activities

To support the strategic direction, the Iowa DOT developed a TSMO Strategic Program Plan that defines a set of activities the Department should engage to improve its ability to operate and proactively manage the state's transportation system. More specifically, the TSMO Strategic Program Plan establishes a set of specific actions needed to achieve the TSMO vision so that TSMO can be better integrated into the Department's core mission. In this vein, the Program Plan provides the organizational, procedural, and resource framework needed to move TSMO from a group of ad hoc activities and services to an integrated approach. Included in the recommendations for TSMO activities was a desire to:

- Improve operations along interstate corridors
- Engage Districts in planning and implementing the TSMO Program
- Develop sustainable strategies to maintain momentum of regional TIM activities
- Support efforts by MPOs to incorporate operations into regional planning
- Identify opportunities to engage local agencies responsible for operating traffic signal systems to discuss ICM

Building from TSMO planning efforts and the aforementioned recommendations, in fall 2018 the Iowa DOT began a process to identify, evaluate, and prioritize ICM strategies within the Des Moines Metropolitan Area. This Phase 1 Strategies Report discusses the process to identify ICM strategies in the Des Moines Metropolitan Area in support of the Department's TSMO Program.

1.1 DOCUMENT PURPOSE

As an initial step toward improved TSMO in Iowa and more specifically to proactively manage traffic, the Iowa DOT initiated an effort to implement ICM strategies within the Des Moines Metropolitan Area. An initial activity conducted as part of this effort included the identification of ICM related strategies that could potentially be implemented to address regional needs. This report documents the project identification process, focusing on the activities leading up to the identification of highly desired strategies that may serve to address needs and that may warrant further investigation.

1.2 BACKGROUND

Congestion on the Iowa Urban Interstate system is trending upwards as measured by the percentage of congested urban Interstate or Freeway lane miles. The percentage of congested urban interstate lane miles has increased from 36 in 2009 to just over 40 percent in 2011, which ranked Iowa 32nd among the 50 states, and puts it in the "bad" category (Hartgenm, Fields, & Feigenbaum, 2014). About 72 percent of congestion in Iowa is caused by temporary disruptions in traffic known as "non-recurring" congestion. The four main causes of non-recurring congestion in Iowa are traffic incidents, work zones, bad weather, and special events. The remaining 28 percent of congestion is referred to as "recurring" congestion, and is attributed to bottlenecks and poor signal timing typically duing "peak hour" traffic periods where there are more vehicles than enough roadway capacity to meet the demand. Compared to the rest of the nation, Iowa has less congestion from bottlenecks and more congestion from bad weather.[1]

In January 2016, the Des Moines Metropolitan Planning Organization published its Congestion Management Process report. The report states that in the next 35 years, the population of the Greater Des Moines population will grow from roughly 500,000 people to approximately 750,000—an increase of roughly 250,000 people. Furthermore, the report states that "this growth will have an impact on the region's streets and highways, and will inevitably lead to increased levels of congestion." The MPO suggests that the region cannot simply build its way out of congestion by adding capacity, but rather must consider alternative strategies to cost-effectively address increasing traffic.

To better understand the nature and extent of congestion in the Des Moines Metropolitan Area, the Des Moines MPO uses model outputs based on real-time data to identify areas of congestion. The MPO then uses a point system detailed within their Congestion Management Plan (CMP) that integrates the values associated with the performance measures of travel time index and planning time index to determine if a roadway is considered congested. Using the methodology in the CMP, roadway segments that receive a combined score of seven or greater are considered to be congested. Congested roadways within the Des Moines Metropolitan Planning Area boundaries for years 2014 and 2015 are plotted on the maps in Figure 1 and Figure 2, respectively. A comparison of congested roadways between these these two maps indicate that congestion in the Des Moines Matropolitan Area, and more specifically the project area, is gretting worse.

[1] Transportation System Management and Operations (TSMO) Strategic Plan, Iowa Department of Transportation, February 2016.

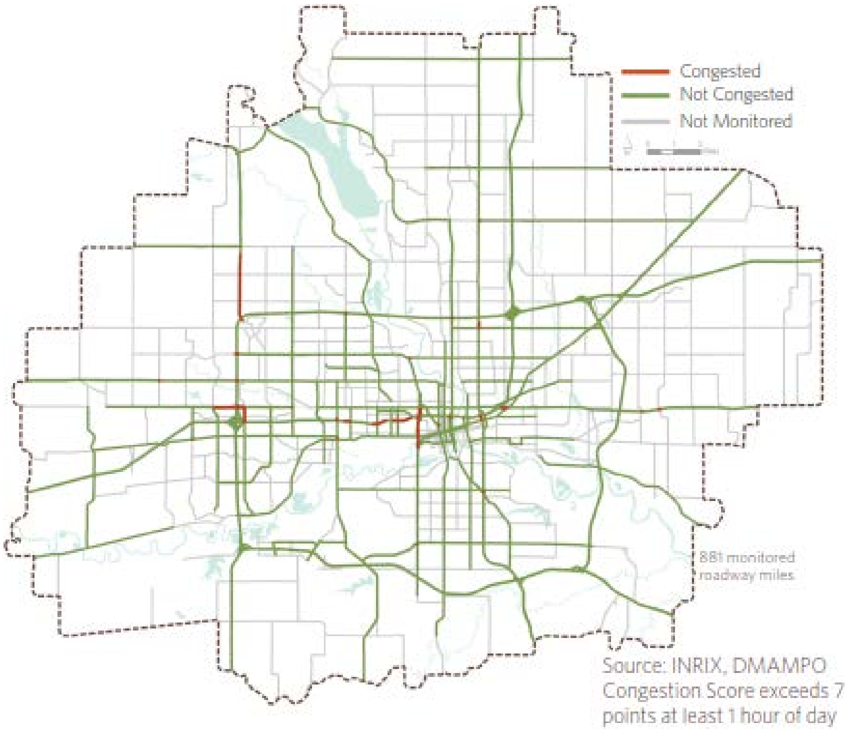

Table 1: Travel Time Index Points

Travel Time Index	Points
0 – 1.30	0
1.301 – 1.50	2
1.501 – 2.00	4
2.001 – 3.00	6
>3.000	8

Table 2: Planning Time Index Points

Planning Time Index	Points
0 – 1.30	0
1.301 – 1.50	1
1.501 – 2.00	2
2.001 – 3.00	3
>3.000	4

Figure 1: Congested Roadways within the Des Moines MPO Planning Area (2014)

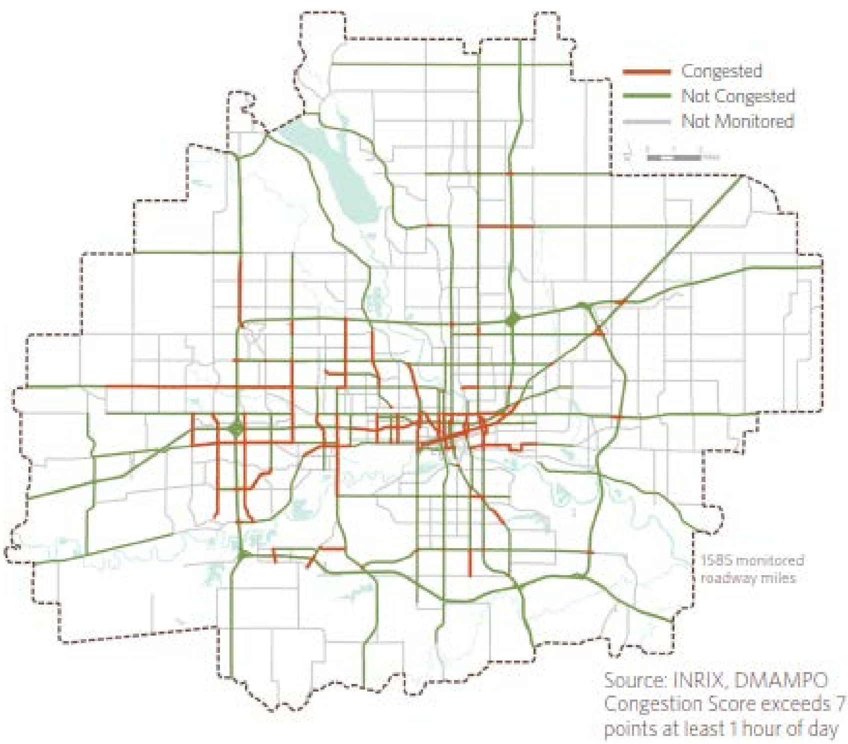

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Figure 2: Congested Roadways within the Des Moines MPO Planning Area (2015)

1.3 WHAT IS INTEGRATED CORRIDOR MANAGEMENT?

The ICM concept represents a framework for multi-modal, multi-jurisdictional coordination to deliver a safer, more reliable, and more convenient transportation system for all users and in a more cost-effective manner compared to traditional capacity expansion projects. The ICM approach is based on proactively managing and operating the regional transportation system within a corridor as an integrated system rather than as individual roadway networks. As traffic volumes grow and as incidents and construction activities occur, managing the Des Moines Metro Area surface transportation system holistically will allow the Iowa DOT and other local and regional agencies to more effectively manage transportation demand using available capacity where it exists, by leveraging capacity on adjacent or parallel networks; improving the operating capability through operational improvements, technology, traffic engineering, and minor roadway improvements; and/or by promoting the use of transit to move greater numbers of people using less vehicles. Furthermore, the Iowa DOT desires to use ICM strategies cooperatively to proactively manage traffic under all types of traffic conditions to deliver improved levels of safety, efficiency, reliability, productivity, and quality of life for all users.

1.4 WHY IS INTEGRATED CORRIDOR MANAGEMENT NEEDED?

Transportation corridors that frequently experience congestion often have available capacity in some of the modes or facilities within the corridor. The available capacity can be enhanced by improved transportation management techniques and used to more effectively balance transportation demand among the facilities and modes within the corridor. ICM attempts to integrate these individual transportation facilities and resources that comprise a corridor or numerous interconnected corridors to maximize use of available capacity (i.e., pavement or vehicles) and to increase person and freight throughput within and through the corridor. The basic premise behind ICM is to operate individual transportation networks (both roadways and multi-occupant forms of transportation) in a more integrated, cohesive manner, rather than the traditional approach that applies operational improvements independently and without consideration of how they can work together to improve corridor operations. The ICM approach reduces or eliminates the adverse impacts congestion causes to safety, mobility, and economic productivity. Like several forward-thinking DOTs, the Iowa DOT recognizes that operating individual networks independently is an inefficient method of allocating transportation demand across available transportation capacity. By integrating transportation facilities and resources, the Iowa DOT will optimize transportation efficiency on a near real-time basis working to balance demand across the entire network—and in doing so will maximize the benefits of existing transportation investment.

1.5 REPRESENTATIVE BENEFITS

ICM strategies can deliver a safer, more reliable, and more convenient transportation system for all users in a more cost-effective manner compared to traditional capacity expansion projects. As traffic volumes grow and as incidents, weather and construction activities occur, actively managing transportation networks will allow the Iowa DOT and other local and regional partners to more effectively manage transportation demand using available capacity where it exists, either by optimizing freeway operations, leveraging available capacity on adjacent or parallel facilities, and/or by promoting the use of transit or new forms of mobility to move greater numbers of people using fewer vehicles. While the benefits of ICM will vary depending on corridor characteristics and the application of operational strategies, it can be expected to benefit transportation in the following ways:

- **Improved safety and emergency response** – ICM strategies can reduce primary and secondary crashes improving safety for motorists, pedestrians, emergency responders, and construction workers. Furthermore, by reducing congestion and vehicle delay, emergency responders can provide more timely response and treatment to injured persons when incidents do occur.
- **Improved accessibility and mobility** – ICM strategies can improve first and last mile connections between modes which in turn can improve transportation accessibility for all users.
- **Reduced or shifted demand** – At the heart of ICM is the ability to balance transportation demand among networks where excess capacity exists. Additionally, ICM offers the ability to reduce or eliminate demand altogether which helps to improve mobility and traffic flow.
- **Enhanced traveler choice and decision making** – ICM strategies can improve access to timely, accurate, and useful travel information to promote driver choice as to which facility or mode to use, empowering users to be in control of their individual trips. As such, users may elect to take routes with less delay, shift modes, and/or shift the timing of their trips.
- **Increased return on and use of existing investment** – ICM helps maximize use of existing services and infrastructure, increasing the public's return on investment.
- **Improved transportation efficiency and productivity** – By reducing congestion and providing drivers with choices in how they can reach their destinations, drivers including freight vehicle operators can arrive to their destinations more quickly.
- **Institutional cooperation** – Since ICM strategies often overlap jurisdictional boundaries, they have potential to bring together and improve collaboration among transportation agencies. This can improve information and data sharing and result in greater efficiencies in traffic management
- **Reduced environmental impact** – ICM can reduce stop and go driving behavior and in turn improve vehicle fuel efficiency and reduce the amount of emissions released into the atmosphere.
- **Improved customer experience and perception** – ICM strategies can improve the customer experience through the aforementioned benefits. This in turn can improve the public's perception of transportation agencies ultimately leading to greater support and funding for effective strategies.

2 Project Overview

2.1 PROJECT PURPOSE

The purpose of the Des Moines Metropolitan Area ICM Project is to implement ICM strategies and select capacity improvements to cost effectively and proactively manage traffic in the Des Moines Metropolitan Areas.

2.2 PROJECT AREA

The limits of the Des Moines ICM project area are:

- I-235 Southwest Junction to Northeast Junction with I-35/I-80
- I-80 US Hwy 169 (Desoto) to 1st Avenue (Bondurant/Altoona)
- I-35 – Iowa 5 (West Des Moines) to 36th Street (Ankeny)
- US 65 – I-80 to Iowa 163 (Pleasant Hill)
- Non-Interstate highways and arterials connecting to roadways above.
- Selected parallel arterials to the freeway system

The extents of the ICM project area are shown in Figure 3.

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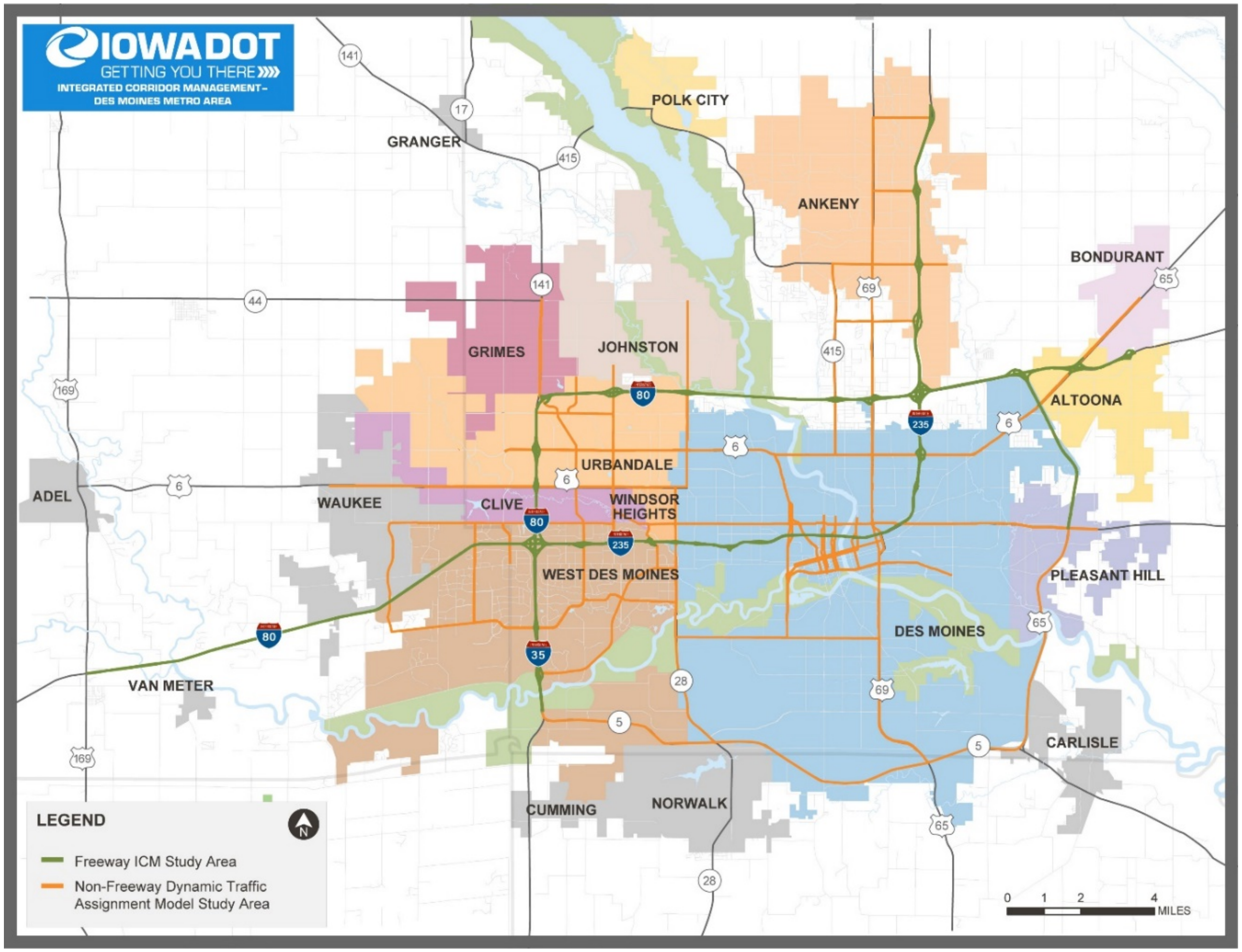


Figure 3: Des Moines Metropolitan Area Integrated Corridor Management Study Area

2.3 SCHEDULE

Figure 4 illustrates the Des Moines ICM project schedule. As shown, the ICM Project began in October 2018 with a stakeholder workshop that kicked off the project. Following this workshop, the Iowa DOT conducted an existing conditions assessment and engaged stakeholders to identify user needs. This report represents the next logical step in the process and is orientated toward identifying and prioritizing specific strategies to address identified needs. ICM strategies will form the basis for developing an ICM program level concept of operations document which formally began with a Concept of Operations workshop conducted in late March 2019. In July 2019, the Iowa DOT will conduct a third workshop focused on the implementation of ICM strategies identified in the program level Concept of Operations and subsequently developed project-level Concept of Operations. In fall 2019, the project will deliver strategy-specific Implementation Plans focused on ICM improvements that can be implemented in the next 2 years. The project will conclude in late 2019 or early 2020 with a public information meeting. The Iowa DOT plans to continue developing and potentially implementing mid- to long-term ICM strategies after the project's conclusion.

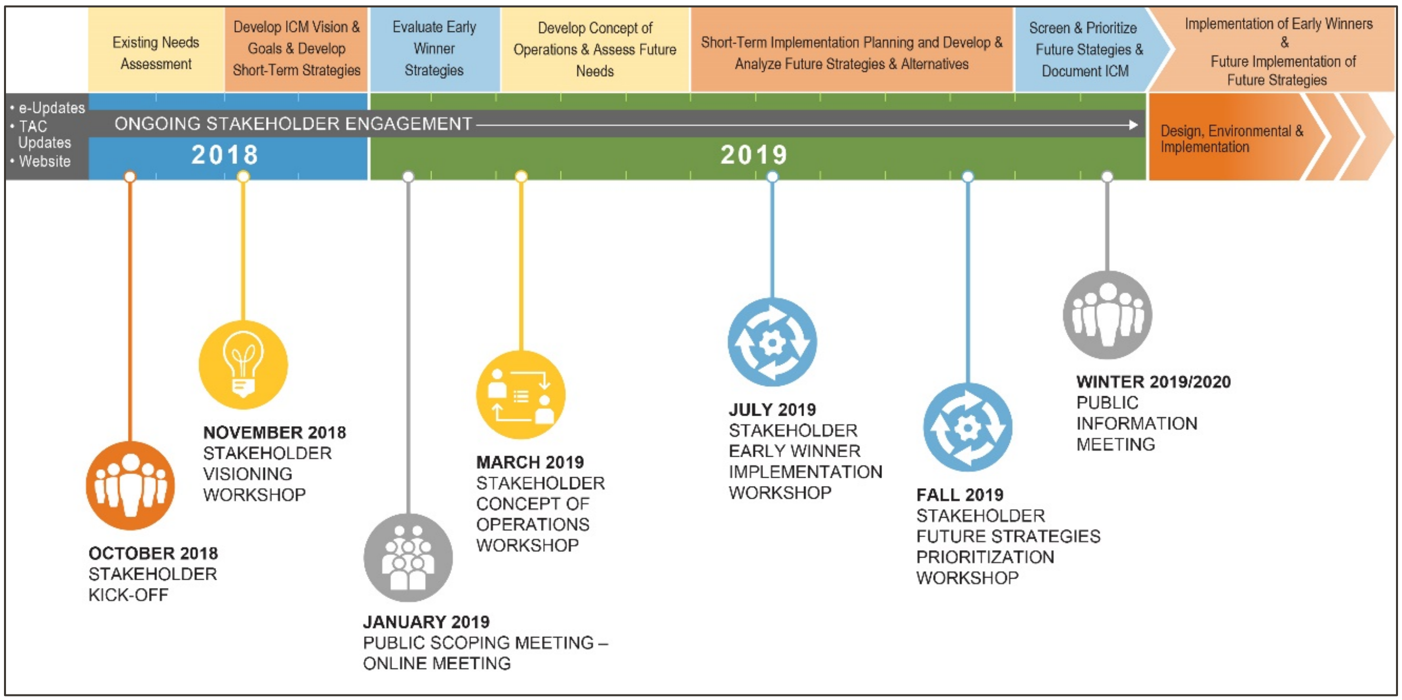


Figure 4: Des Moines Integrated Corridor Management Project Schedule

3 Existing Conditions

As an initial step in the ICM strategy development process, an existing conditions analysis was conducted for the transportation system in the study area. The results of this analysis are presented in detail in **Appendix A** and summarized in this section.

The existing conditions assessment was derived from a quantitative analysis of historical traffic data related to safety, mobility, and reliability of the transportation network within the Des Moines ICM study area. Data used in the analysis were made available by the Iowa DOT, and data providers with which the Iowa DOT has agreements. The result of these data analyses are corridor and segment level metrics that helped shape the vision, goals, and objectives of the ICM program, and will be used to measure progress in achieving the goals. The existing conditions assessment also provides a segment-level assessment of performance metrics that do not meet recommended performance thresholds as drafted by the project team and confirmed by the Iowa DOT. The segment-level assessment will also help frame near-term and longer-term strategies.

The existing conditions analysis focused on reliability, mobility, and safety metrics as described below and in Appendix A. Results of the analysis indicate that the study area exhibits safety, mobility, and reliability challenges.

3.1 TRAVEL TIME RELIBAILITY ANALYSIS

Travel time reliability describes how congestion varies from day to day, indicating how predictable travel conditions are on a facility. The following metrics were analyzed

- Speed Profiles
- Speed Trends
- Travel Time Distributions
- Overall Reliability Trends

Reliability analysis shows that the east-west portion of I-235 and the north-south portion of I-35/I-80 experience the highest percentage of segments with speeds at 45 mph or below, but most other freeway segments fall within the moderate range for multiple travel time-based performance measures. With a trend of decreasing reliability at the system level over the 5-year period, the full length of I-35/I-80 and I-235 could benefit from reliability-enhancing strategies.

3.2 MOBILITY ANALYSIS

Mobility analysis identified the primary sources of congestion: bottlenecks, weather, incidents/crashes, and construction/work zones. The hours of congestion analysis identified increasing levels of slow roadway speeds regardless of source of congestion. The volume-based bottleneck analysis showed that much of the freeway system on both I-35/I-80 and I-235 are exhibiting Level of Service (LOS) D as a worst-case condition. The Highway Capacity Manual describes LOS D as restricted flow and regular delays, a description that lines up well with previously described reliability findings. The recurring delays on these corridors are exacerbated by other sources of congestion that lead to more significant breakdowns. One source known to have significant effects statewide is adverse weather. As of yet, data from the NWS has yet to be tied directly to speed data and the calculation of hours of congestion, though this remains a future opportunity. The sources of construction and crashes/incidents were examined at the corridor and segment level to determine the impact they have on mobility. Construction identified by the TMC was typically work at night and caused little impact to roadway speeds. Conversely, crashes and incidents tended to flare up during the peaks and resulted in 350 to 400 hours of congestion each year across all segments.

Further, the mobility analysis looked at traffic volumes as an indicator of slow speeds and likely breakdowns and found that much of the core freeway loop is operating at LOS D for worst-case peak conditions with a potential bias toward missing LOS E/F segments when estimating mobility based on sensor counts and not demand volume. With heavy volumes creating pressure on the system, the analysis of source congestion shows that crashes and incidents add to recurring peak congestion because they are concentrated during the peaks. There is a spike in hours of congestion when crashes or incidents are present.

3.3 CRASH ANALYSIS

There were 24,680 crashes on freeways and major roads in the study area between 2013 and 2017. In this same period 460 people were killed or suffered major injuries. Most of the crashes in the study area are possible injury or property damage only. Crash trends do show an increase in the number of crashes during this period. In addition, there is a significant increase in the number of crashes on the major roads between 2014 and 2015 and sustained through 2017 that deserves more research. Trends that may respond to ICM strategies include the frequency of crashes with contributing factors related to surface condition, work zones, congestion, and incident related congestion. On both freeways and major roads, crashes were most frequently attributed to: following too closely, driving too fast for conditions, and failure to yield to right of way. Managing traffic flow may reduce the risk of these crashes. The average crash rate for much of the system is relatively high compared to the statewide average. Therefore, comparing crash costs and hot spots provides a means of assessing where crashes may be over-represented and the severity of crashes on the system. On the freeway system, the northeast and southwest junction appear as priority locations.

Crash rates on key roadways in Des Moines routinely exceed statewide averages, though many segments with high crash frequencies are predominantly experiencing property damage only crashes.

4 Regional Needs Identification

Successful ICM strategy deployment must be based on the identification and analysis of transportation user needs. User needs specify the issues impacting travelers and transportation operating agencies and analyzing these needs helps to determine how ICM can best address them. Identifying transportation user needs is important because they provide the foundation from which specific ICM strategies are formed and ultimately projects developed to meet specific regional ICM goals and objectives.

User needs, in combination with existing conditions, provide the required understanding to begin to outline an approach for improving transportation within the Des Moines Metropolitan Area. More specifically, this understanding lays the framework for developing a vision and corresponding goals and objectives for the ICM Program.

4.1 KEY ICM FACTORS

Key ICM Factors were selected through an interactive exercise in a workshop environment. A preliminary list of factors was provided that reflected priorities documented in other transportation planning activities (e.g., Des Moines Area Metropolitan Planning Organization. *Mobilizing Tomorrow – A Transportation Plan for a Greener Greater Des Moines, and Iowa Transportation Systems Management and Operations (TSMO) Program Plan Version 1.0.*). Through a voting process, workshop participants prioritized these key ICM factors to help define the vision, goals, objectives, and performance measures for the Des Moines ICM project. Provided below is a prioritized list of these factors and key considerations.

1. **Safety** - ICM strategies must address speeding. Speeding is an increasing problem that is significantly impacting safety.
2. **Mobility** - ICM strategies must address mobility for all travelers.
3. **Reliability** - Reliability is significantly impacted by safety and mobility issues. Strategies that address reliability must also consider transit services.
4. **Integration** - Integration must address first mile/last mile issues. Integration must support multi-modal travel and consider regional connections.
5. **System Preservation** - ICM strategies must address fiscal considerations. Expansion of technologies, services, or infrastructure should not happen until they can properly be operated and maintained. Core assets must remain in a state of good repair, regardless of whether it is the roadway network, field devices, vehicles, or any other infrastructure components.
6. **System Management** - System management must address the entire transportation network and cross jurisdictional boundaries. The transportation system is multi-jurisdictional and multi-modal.
7. **Accessibility** - Accessibility means all travelers arrive safely and efficiently at their destination regardless of mode. Accessibility also means providing affordable travel options for all travelers.
8. **Regional Economic Vitality** - ICM strategies help foster a healthy regional economy.

4.2 NEEDS STATEMENTS

Stakeholders were also given the opportunity to submit comments on issues that must be included in the Des Moines ICM project vision. The following statements were provided during the Visioning Workshop to help guide the definition of the Des Moines ICM vision.

- The success of the Des Moines ICM project will be predicated on active and sustained stakeholder engagement. Engagement over time will also evolve to include additional stakeholders and partners.
- ICM solutions need to focus on providing predictable and reliable travel in the Des Moines Metropolitan Area.
- ICM solutions should support the advancement of a vital economy.
- It is necessary to be proactive in identifying potential funding sources, perhaps those that include contributions from multiple jurisdictions.
- ICM strategies need to be cost effective and maximize operational benefits.
- ICM strategies must be sustainable in the context of current management and maintenance programs.
- ICM solutions must maintain and preserve the built and natural environment.
- ICM solutions need to focus on emerging trends such as connected vehicles (CV) and automated vehicles (AV).
- Consideration must be given to how ICM strategies will impact all transportation system users.
- ICM solutions need to address commuter options such as telecommuting, and not just during adverse weather conditions.
- ICM solutions need to foster interconnection of systems, and be flexible and adaptable to changing conditions.

5 Regional ICM Vision, Goals, Objectives and Performance Measures

The process of defining the Des Moines ICM vision, goals, objectives, and performance measures was facilitated through an examination of existing conditions, and interactive exercises that were conducted in a workshop environment. An overview of these activities is provided below.

Existing conditions and operational challenges in the region were examined to identify where and how ICM strategies could potentially be implemented to address these challenges. Based on the input of stakeholders the following vision statement, goals, objectives, and performance measures have been developed for the Des Moines ICM project.

5.1 VISION STATEMENT

The Des Moines ICM project vision statement articulates a shared purpose for the regional stakeholders to work toward. It is oriented toward high-level outcomes and reflects the needs of the range of stakeholders involved in the project. This helps to ensure that it reflects the overall visions and missions of the individual agencies. Key principles guiding the development of the Des Moines ICM vision statement are that it be:

- Future oriented,
- Leads to a better future,
- Represents stakeholder values,
- Sets standards of excellence,
- Rooted in the purpose and direction of the region,
- Inspires stakeholder enthusiasm, collaboration and commitment,
- Reflects unique aspects of the region, and is
- Ambitious.

The Des Moines metropolitan area will benefit from a safe, efficient, reliable and sustainable transportation system that supports economic growth and promotes equitable transportation services and a healthy community. ICM strategies will assist the state and area communities to proactively manage multi-modal transportation systems in a safe and efficient manner using proven technologies and operational strategies while maximizing the use of existing infrastructure and services. ICM will offer travelers more opportunities to make convenient trips to meet social and economic needs.

5.2 GOALS

Goals that have been identified for the Des Moines ICM project are broad aspirations or outcomes for the region and directly relate to factors important to stakeholders (e.g., safety, mobility, and system preservation). Table 3 lists the goals that have been identified for this effort.

Table 3: Des Moines Metropolitan Area ICM Goals

Factors	Goals
Safety	Reduce fatalities and serious injuries on public roads in the region.
Mobility	Provide options to travelers that minimize time spent traveling.
Reliability	Improve efficiency and predictability of travel in the region.
Integration and Connectivity	Provide transportation that allows travelers to make efficient and seamless multi-modal trips throughout the region.
Accessibility	Improve traveler's overall ability to reach key destinations such as jobs, schools, libraries, health care, shopping, and entertainment.
Regional Economic Vitality	Use the regional transportation system to foster a thriving, competitive regional economy.
System Preservation	Maintain transportation infrastructure in a state of good repair.
Systems Management	Improve the efficiency of the surface transportation system.

5.3 OBJECTIVES

Objectives for the Des Moines ICM project support specific goals and provide additional details, or strategies, on how the goal will be achieved. Table 4 provides an overview of the objectives that have been identified for the Des Moines ICM initiative.

Table 4: Des Moines Metropolitan Area ICM Objectives

Factors	Objectives
Safety	• Reduce number of traffic fatalities. • Reduce number of serious injuries. • Reduce pedestrian and bicycle fatalities.
Mobility	• Reduce congestion in key commuter corridors. • Reduce congestion in key freight corridors. • Provide travel options for transportation system users. • Provide transit service connecting major activity centers within the Des Moines metropolitan area. • Provide more dedicated bicycle facilities. • Provide more sidewalks for pedestrians. • Reduce single occupancy vehicle (SOV) trips.
Reliability	• Reduce the variability of travel time on key commuter routes and modes. • Improve average on-time performance for transit services.
Integration and Connectivity	• Improve multi-modal connections between bicycle, pedestrian, transit, and private vehicle travel. • Improve system connectivity through improved multimodal connections and reduced network gaps.
Accessibility	• Provide transit service throughout the Des Moines metropolitan area. • Improve proximity to multi-modal transportation. • Improve ADA accessibility. • Improve service for traditionally underserved populations.
Regional Economic Vitality	• Facilitate the efficient and safe movement of freight and goods.
System Preservation	• Preserve and maintain pavement.

Factors	Objectives
	• Preserve and maintain bridges. • Preserve and maintain bicycle trail systems. • Preserve and maintain sidewalks. • Support urban development projects with necessary transportation investments.
Systems Management	• Implement metro-wide demand management strategies. • Implement employer-based demand management programs at major employers. • Implement ITS technologies along priority commuter and freight corridors. • Implement advanced operational strategies along priority commuter and freight corridors.

5.4 PERFORMANCE MEASURES

FHWA defines performance measurement as the use of statistical evidence to determine progress toward specific defined organizational objectives. In the context of ICM projects effective performance measures should be:

- Accepted by and be meaningful to the range of project stakeholders,
- Explain how the goals and objectives are being met,
- Simple, unambiguously defined, understandable, logical and repeatable.[2]

Table 5 lists the performance measures that may be considered for evaluation of progress toward the objectives for the Des Moines ICM project. It is important to note that with the identification of ICM strategies specific to this effort the list of performance measures will be refined based on the functionality of prioritized strategies. The final selection of performance measures will be largely driven by the availability of data.

Table 5: Des Moines ICM Performance Measures

Factors	Performance Measures
Safety	• Number of fatalities • Rate of fatalities per 100 million vehicle miles traveled (VMT) • Number of serious injuries • Rate of serious injuries per 100 million VMT • Non-motorized fatalities • Non-motorized serious injuries
Mobility	• Vehicle miles traveled • Person miles traveled • Truck miles traveled • Transit ridership • Average travel speed • Vehicle delay • Person delay • Level of Service (LOS) • Percent of miles heavily congested

[2] https://ops.fhwa.dot.gov/perf_measurement/fundamentals/

Factors	Performance Measures
	• Duration of congestion • Mode share • Bicycle infrastructure usage • Single Occupant Vehicle (SOV) trips
Reliability	• Percent of the Person-Miles Traveled on the Interstate that are reliable • Percent of the Person-Miles Traveled on the Non-Interstate NHS That Are Reliable • Truck Travel Time Reliability (TTTR) Index • Annual Hours of Peak Hour Excessive Delay Per Capita • Percent of Non-SOV Travel • Transit on-time performance
Integration and Connectivity	• Passenger travel time • Connectivity gaps in multimodal transportation systems
Accessibility	• Percent of population and employment close to pedestrian, bicycle, car share, bike share, and transit facilities • Awareness and use of transportation demand management (TDM) programs by residents, workers, and visitors • ADA accessibility to Des Moines Area Rapid Transit and Heart of Iowa Regional Transit Agency (HIRTA) services
Regional Economic Vitality	• Job growth • Unemployment rates • Home sales • New residential construction • Rental vacancy rates • Building permits
System Preservation	• Pavement condition • Bridge condition • Bicycle trail condition • Sidewalk condition • Percent of deficient bridges • Average age of DART's fleet • Number of transit vehicles past their useful life
Systems Management	• Average travel speed • Vehicle delay • Person delay • LOS • Percent of miles heavily congested • Percent of travel heavily congested • Duration of congestion • Bicycle infrastructure usage • SOV trips • Percent of telecommutes • Flexible work hour programs

6 ICM Strategy Identification and Development

Based on the ICM vision, goals, and objectives previously defined, the Iowa DOT in cooperation with their regional partners, identified a range of potential ICM strategies that could be applied within the project area. These strategies were in part identified using previous planning efforts and then narrowed through analysis and stakeholder outreach. Together, the ICM strategies identified and presented in this chapter offer potential to address the ICM vision, goals, and objectives. However, the full range of strategies presented will eventually need to be further narrowed and screened to arrive at a set of strategies that are realistic in terms of agency constraints such as available funding, operations and maintenance requirements, project delivery timeframes, and potential impacts–both positive and negative. Ultimately, those strategies selected for implementation will be further studied to refine each with respect to specific stakeholder roles and responsibilities for planning, developing, implementing, and operating project elements.

6.1 ICM STRATEGY CLASSES

A true ICM approach embodies strategies that can be implemented or leveraged to cost effectively balance demand using existing available capacity. This often constitutes consideration of a range of strategies from system modifications (i.e., pavement or infrastructure modifications) to changes in policies and procedures to integration of new equipment and often more advanced and innovative tools. This section identifies potential ICM strategies identified through examination of existing literature and through stakeholder engagement. Strategies identified vary in level of sophistication, understanding and deployment. ICM strategies are organized into the five categories shown in Figure 5, and described below.

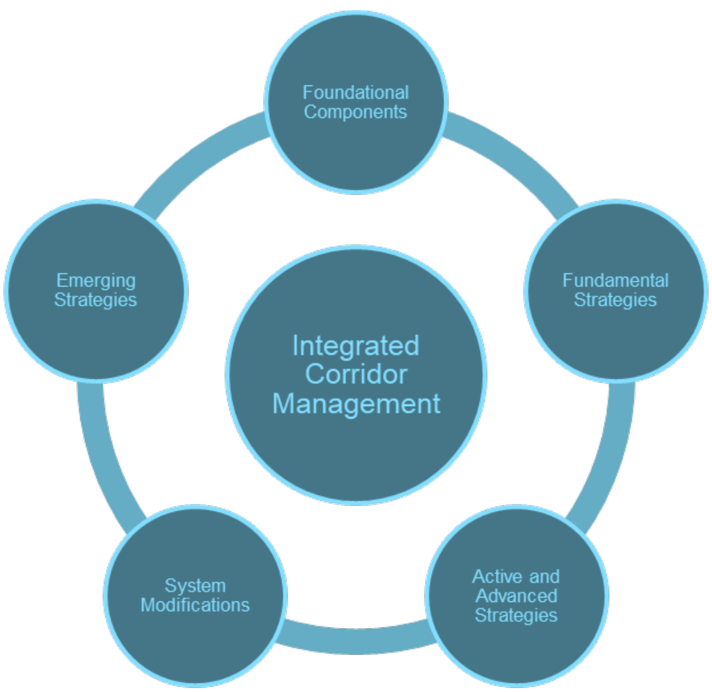


Figure 5: Potential ICM Strategy High-level Categories

- **Foundational Components** – Foundational components represent the basic transportation management elements that are commonly used by most transportation agencies today. These strategies support fundamental, active/advanced, and emerging strategies and enhance the ability of agencies to better manage the performance of the transportation network. These components generally represent the basic data collection, processing, communications and information dissemination elements to make real-time traffic management decisions.
- **Fundamental Strategies** – Fundamental strategies represent improvements that are widely implemented by transportation agencies. These strategies represent the building blocks from which more active and advanced strategies build from. The impacts of these strategies are well known and may require less effort to plan for when compared to more active and advanced strategies. These strategies in general have been used by transportation agencies for more than a decade.
- **Active and Advanced Strategies** – Active and advanced strategies represent improvements that build upon foundational and fundamental strategies and add a layer of increased sophistication to them to improve operational benefits. These strategies have begun to emerge over the last decade but have yet to be widely implemented. While the benefits of these strategies have begun to be documented in literature, research on their impact is on-going.
- **System Modifications** – These improvements either add to or make modifications to existing transportation infrastructure to cost effectively enhance operations. These modifications are limited in scope and are implemented at specific locations in the transportation network and support other types of transportation improvements. Approaches use the road space more efficiently to reduce congestion and improve safety.
- **Emerging Strategies** – These strategies represent the leading edge of transportation innovations, and may have either been recently implemented in practice or have yet to be implemented. These strategies are rapidly evolving and are relatively unfamiliar to the many transportation practitioners. Many emerging strategies are currently within or just emerging from pilots or research stages. These strategies may be able to produce even greater benefits when compared to less sophisticated strategies. However, expected benefits are still conceptual or still evolving to the point where there is little certainty or confidence in exactly what their return will be. The full benefits of emerging strategies may not be fully realized at implementation and may require greater penetration rates of related technologies to be fully captured.

6.2 ICM STRATEGIES

While the ICM strategy categories listed above present one way to understand how ICM strategies build upon or support each other, another way to understand them is by organizing them by their transportation functional area. To that end, potential ICM strategies can support the seven functional areas listed in Figure 6. These functional areas represent Des Moines' ICM Program Elements. Under each Program Element, potential ICM strategies that support that element are listed. More detailed descriptions of each strategy are provided in individual strategy tables found in Appendix B.

Figure 6: Des Moines Metropolitan Area ICM Program Elements

7 ICM Strategy Evaluation

Using the pool of potential ICM strategies identified in the previous section, the Iowa DOT conducted a multi-step evaluation to identify those that provide the best value to travelers in the Des Moines Metropolitan Area. The current process (Phase 1) focuses on evaluating ICM strategies that are low cost, can be implemented quickly (in the next 1 to 2 years), and can be spearheaded by the Iowa DOT. The Phase 1 process includes multiple screening criteria to identify and evaluate potential strategies. Note that all remaining ICM strategies previously outlined in the Range of Potential ICM Strategies will remain in consideration for medium-term (Phase 2) and long-term deployment. These strategies will be evaluated at a later stage in the project with a similar multi-step process.

The goal of the near-term Phase 1 evaluation process is to:

- Deploy ICM strategies that address needs based on the Existing Conditions analysis.
- Deploy ICM strategies with visible benefits in a timely manner to garner project support from stakeholders and the public.
- Deploy ICM strategies that reinforce the Des Moines ICM vision.

The near-term ICM strategy evaluation process is as follows:

1. Screening for Near-Term Implementation Hurdles
2. Strategy Deployment Action / Location Refinement
3. ICM Action Evaluations

7.1 SCREENING CRITERIA

The ICM strategy evaluation process began with an identification and subjective assessment of near-term implementation issues. Each issue identified below was considered a potential challenge to successful near-term implementation; therefore, any strategy meeting one or more of the criteria below were screened and eliminated from near-term deployment. Every strategy not passing the screen will be retained for further consideration for mid- or long-term deployment.

- **Controversial** – Any ICM strategy that has the possibility of being controversial will require more elaborate planning and education than can be accommodated by the near-term deployment schedule.
- **Substantial Preparation for Deployment** – Any ICM strategy that requires environmental documents, permits, procurement, design, purchase of right of way, or has legal/regulatory/legislative barriers cannot be accommodated by the near-term deployment schedule.
- **Substantial Interagency Coordination/Agreements** – Any ICM strategy with field deployment contingent on substantial interagency coordination and/or agreements cannot be accommodated by the near-term deployment schedule. However, the initiation of interagency coordination and/or agreements can be foundational to near-, medium-, and long-term deployment success.
- **Unsatisfied Prerequisites** – Any ICM strategy that requires prerequisite capabilities that are not already in place is not well aligned with the near-term deployment approach.

- **High Deployment Cost** – Any ICM strategy that requires a high deployment cost is not well aligned with the near-term deployment approach.

7.2 STRATEGY DEPLOYMENT ACTION/LOCATION REFINEMENT

The ICM strategies that remain for near-term evaluation beyond the screening stage provide a range of potential Phase 1 implementation strategies that require further refinement. A portion of that refinement is moving from the ICM strategy level (purposefully generic) to a specific ICM action. For example, Traffic Incident Management (TIM) is an ICM strategy. TIM can be deployed in many ways to successfully improve preparation and response to traffic incidents. A TIM action may consist of stationing TIM equipment near one or more long-term work zones. By refining the ICM strategies to ICM actions the evaluations can point to specific benefits from past deployments in other locales as opposed to assigning a blanket assessment to the strategy. Further, the near-term deployment approach may function as a localized test for a particular ICM strategy that will be deployed in a more widespread fashion in the long-term ICM strategy recommendations.

The approach employed at this step of the process involves highlighting key need areas (based on the existing conditions analysis and stakeholder input) to target and assign well-aligned ICM strategies to targeted needs. The ICM action identification process will leverage strengths of multiple team partners, accounting for strengths in understanding local conditions and experience with the outcomes of past ICM strategy deployments. The ICM action identification process is intended to produce a menu of options for targeted need areas, where each item off the menu will be evaluated.

The following sections discuss the ICM actions formulated by the project team. The ICM actions naturally fall into two categories: 1) Foundational ICM actions and 2) Early Winner deployments.

7.3 ICM ACTION EVALUATION

The ICM actions defined by the project team were evaluated on multiple criteria to guide future screening and prioritization in partnership with the Iowa DOT. The Phase 1 ICM strategy evaluation process focused on evaluating ICM actions at the qualitative level, recognizing that further evaluation will occur at a later stage in the process as these ICM actions are defined through the future program-level Concept of Operations and through individual Implementation Plans.

The evaluations focused on the primary goals and objectives previously identified. Proposed Phase 1 criteria include the following:

- Foundational to ICM Strategies
- Safety – Includes: 1) Reduces Fatal and Injury Crashes, 2) Reduces Crashes (All Severity Levels), 3) Reduces Secondary Crashes, and 4) Reduces Crashes on Primary ICM Corridors.
- Mobility – Includes: 1) Reduces Congestion/Improves Travel Times on Commuter Corridors, 2) Reduces Congestion/Improves Travel Times on Freight Corridors, 3) Provides Choices

and Travel Options, and 4) Reduces Congestion / Improves Travel Times at the Regional Level.

- Reliability – Includes 1) Reduces Travel Time Variability on Commuter Corridors, 2) Reduces Travel Time Variability on Freight Corridors, 3) Improves Average On-Time Performance, and 4) Reduces Travel Time Variability at the Regional Level.
- Institutional Capability
- Suitability with Other ICM Strategies
- Visibility
- Cost

These qualitative evaluations will use a three-tiered scale applied separately to each criterion. The general scale will be as follows:

Three-Tier Evaluation Scale
Negligible benefit to criterion / Negative benefit based on criterion
Minor benefit to criterion
Major benefit to criterion

The benefit levels were established for each criterion in response to the range of ICM actions remaining for evaluation. The division values were based on a limited amount of planning-level data. Hence, the process required adjustment by professional judgment to properly separate ICM actions that differ significantly in their level of benefit. The proposed evaluations are included as Appendix C.

7.4 ICM STRATEGIES EVALUATED

7.4.1 Foundational ICM Actions

In refining ICM strategies to actions and identifying high-need locations, several ICM actions were identified that are foundational to the aims of the Des Moines metro area ICM project. These strategies do not lend themselves to specific benefits in the safety, mobility, and reliability categories because they function behind the scenes, yet each listed strategy is anticipated to provide efficiencies for more visible ICM deployments.

Arterial Management

- **Build Traffic Signal Inventory Data Portal for Metro Area** – Traffic signals represent a source of delay to metro area travelers that can be easily adjusted to promote a wide variety of system goals. Generally, traffic signals are optimized to promote through capacity on major streets and equitable delay between competing minor street approaches. Where two major streets cross, delays tend to be divided equitably. In most cases this optimization is based on traffic demand data that quickly becomes outdated. Constructing a traffic signal inventory that maintains data on signal detection, phasing plans, latest available traffic counts, signal function (fixed timed, traffic responsive, adaptive) and timing of the latest signal update project would significantly improve management of arterial operations. If selected, Iowa DOT could promote this strategy by developing and maintaining the inventory and providing a data portal that allows local agencies to keep the data up to date and see key information on signals in neighboring communities. The development of this data portal would be foundational to further arterial management, event management, traveler information (including smart cities and connected vehicles), and public transportation management. The strategy also would include development of a standard assessment for traffic signals in need of added functionality (good fit/high priority for adaptive) or updating to current conditions (signal optimization).

- **Develop Communications/Fiber Inventory** – Arterial management and integrated corridor management can be constrained by deficiencies in high-performance communication. Iowa DOT's Intelligent Transportation Systems (ITS) and Communications Systems Service Layer Plan provides documentation of the fiber either owned or leased by Iowa DOT, but gaps currently exist in the communications inventory of metro area agencies. This strategy would be foundational to future design of mid-term and long-term ICM strategies, a future update of the Des Moines Metro Area ICM program-level Concept of Operations, and Des Moines metro ITS systems architecture.
- **Develop Recurring Signal Optimization Program/Dedicated Funding** – Traffic signal timing provides a major element in integrated corridor management, but often is underfunded and re-timing projects are implemented on an ad-hoc basis. This strategy would develop a systematic process for providing funding to critical signal timing projects and through coordination with the Iowa DOT and stakeholders establish the appropriate funding levels to reserve from formula funding or solicit from grant funding. The strategy would develop streamline procedures to limit administration in funding requests to keep arterials operating efficiently. This strategy is foundational to arterial management, public transportation management, and indirectly to freeway management through diversion.

Travel Demand Management

- Update Travel Demand Management Multi-Agency Memorandum of Understanding (MOU) and Conduct Media Campaign – The reconstruction of the Interstate 235 corridor kicked off a period of focused travel demand management for corridor users in 2001. As the metro area has continued to grow, the multi-agency collaboration to support travel demand management has not kept pace. To achieve Integrated Corridor Management, the development of a new memorandum of understanding (MOU) around travel demand management would be foundational in adjusting regional travel patterns toward more system efficient travel. The MOU would build on the project vision and determine partner responsibilities to reduce travel in the metro by single-occupant vehicle during peak periods. The outward manifestation of this multi-agency agreement would be a media campaign with education about travel options and the roles of each partner in supporting high-occupancy vehicle travel.

7.4.2 Early Winner Deployments

ICM strategies in this category were judged to be deployable in the next several years and accomplish a range of objectives associated with making the overall Des Moines ICM project a success. This list was generated as an exercise of matching ICM strategies, post-screening, to existing need areas collected by the project team. The current number of ICM actions were generated to provide a menu of options, with medium priority ICM actions falling outside the Early Winner implementation plan. The low priority ICM actions will be re-evaluated with other longer development ICM projects to determine mid- and long-term priorities as a subsequent task.

Event Management

- **Pre-stage Response Equipment** – An Iowa DOT TIM Service Layer recommendation to provide quick deployment of traffic control at incidents for improved safety. Equipment lists and locations will be developed collaboratively with DOT and stakeholders if this strategy advances.
- **Naming Conventions for System Ramps** – Iowa DOT recently adopted the practice of naming system ramps systematically for emergency response in other urban areas. Extending this practice to Des Moines could provide improved response time and clarity of incident notification.
- **Incident Bypass Routes Trailblazer Sign Deployment** – Iowa DOT has designated incident management routes within the Des Moines metro, but travelers that exit to local diversion routes may have difficulty navigating back to the primary route around an incident. Additional alternate route trailblazer signs may improve wayfinding, reducing out-of-distance travel that impacts trip reliability. Routes appropriate for trailblazer signage will be developed collaboratively with DOT and stakeholders if this strategy advances.
- **TMC Managed Signal Timings for Incident Bypass Routes** – Traffic impacted by an incident may use a signalized bypass route, causing a spike in the demand typically experienced at traffic signals. Unexpected congestion may form and create safety issues if traffic signal timing cannot be managed responsively to the incident bypass traffic. This recommendation builds on the Iowa DOT TIM Service Layer strategy to form agreements between agencies to allow collaborative DOT and local agency response to incident traffic through signal timing. If the strategy is advanced, a pilot signal timing optimization would be conducted based on incident condition data allowing operators to deploy the incident timing plan in the future.
- **Median Barrier Gates** – Emergency responders often struggle to obtain access to freeway incident locations due to permanent physical barriers (median barrier, limits of ramp access) and transient blockages (peak hour traffic navigating or blocked upstream of the incident). At the project visioning workshop, TIM personnel identified that periodic breaks in the center median benefit their operations of responding to incidents. Gates will close these breaks when they are not needed by responders. A number of locations along the Des Moines freeway system may be well suited to median breaks; the consultant team identified the following:
    - Interstate 80 West and East of Northeast mix master
- **Permit Over-Sized Trucks for Off-Peak Only** – Iowa's transportation system allows for the efficient movement of freight, including vehicles designed to require a width greater than 8.5 feet (the federal standard for vehicle width limitation). Iowa DOT already must permit these vehicles to use the system, so this strategy looks to adjust the permit process to limit permits to certain hours of the day. The strategy will provide additional capacity during heavy commute times.

Freeway Management

- **Dynamic Shoulder Lanes/Part-Time Shoulder Use** – In areas where shoulder width and depth are suitable to handle traffic, the use of a shoulder as a temporary lane for traffic can provide substantial increases in roadway capacity. Furthermore, the use of shoulder lanes will help to reduce congestion; however, a tradeoff would be that refuge areas will be limited to only one side of the freeway potentially and adversely impacting emergency responder access to incident scenes. In this strategy, use of the left or inside shoulder is recommended as the right or outside shoulder can continue to function as a vehicle refuge area. Initially, the strategy would look at static, time-of-day shoulder use to reduce needed infrastructure and software for pilot deployment, but ultimately the strategy provides the greatest benefit when managed dynamically. Strategy development would require a concept of operations for the roles of the TMC and emergency responders to confirm the shoulder is clear before and during each time period of part-time use and provide appropriate messaging in advance of decision points.

- Inside shoulder - Southwest mix master to Merle Hay Road

Arterial Management

- **Pilot Arterial Travel Times on Corridor** – The collection and display of travel times along arterial corridors can provide travelers additional options to travelers and support on-time transit operations. The strategy considers deployment of Bluetooth detection at spot locations along an arterial corridor to determine if wider use of arterial travel time collection allows for more advanced transportation management within the metro.
  - University Avenue
  - Grand Avenue
- **Pilot Regional Signal Optimization** – In addition to foundational traffic signal supportive recommendations, this strategy seeks to develop one or more pilot corridors with optimized signal timings based on the vision of the Des Moines Metro Area ICM project. This strategy targets locations with known congestion based on existing conditions analysis and stakeholder input. To be achievable as an early winner, the corridor(s) selected for signal optimization would need to be fairly short, include limited inter-jurisdictional agreements, and likely be heavily or fully funded by Iowa DOT. In that light, the following corridor(s) were evaluated with preference given to corridors that could directly impact congestion near the freeway system. The process piloted through this strategy would be documented and made available to stakeholder agencies to help reduce the cost of subsequent signal optimization projects and recognize the role individual corridors plan in metro-wide integrated corridor management.
  - Iowa Highway 28/63rd Street (I-235 Interchange Area)
  - Oralabor Road (I-35 Interchange Area)
  - Jordan Creek Parkway (I-80 Interchange Area)
  - Hickman Road (I-35/I-80 Interchange Area)
  - 100th Street/Valley West Drive (I-235 to Douglas Street)
  - 60th Street/NW 128th Street (I-80 Interchange Area to Hickman Road)
  - University Avenue (Iowa Highway 28/63rd Street to MLK Parkway/19th Street)
  - Grand Avenue (Iowa Highway 28/63rd Street to Fleur Drive)

Traveler Information

- **Add US 65/Iowa 5 Bypass to Travel Time Comparison via DMS Messaging** – This strategy builds off existing comparative travel time messaging provided by Iowa DOT for the I-235 and I-35/I-80 corridors through the Des Moines metro by adding a third bypass option along US Highway 65 and Iowa Highway 5 to divert regional trips at times when the bypass corridor represents a viable alternative. The third route option would be provided to en-route travelers via DMS at key decision points. As part of this strategy, the TMC would be consulted to determine the quality of real-time travel data available along US Highway 65/Iowa Highway 5 to support the strategy, including potential use of Inrix data. If advanced, the strategy would also need to develop appropriate message protocols to only alert travelers to the bypass route when viable.

- **Add US 65/Iowa 5 Bypass Travel Time Comparison to Truck Information System** – This strategy builds on existing comparative travel time messaging provided by Iowa DOT for the I-235 and I-35/I-80 corridors through the Des Moines metro by adding a third bypass option along US Highway 65 and Iowa Highway 5 to divert regional trips at times when the bypass corridor represents a viable alternative. The third route option would be provided for en-route travelers using Iowa DOT's recently deployed truck information system. As part of this strategy, the TMC would be consulted to determine the quality of real-time travel data available along US Highway 65/Iowa Highway 5 to support the strategy, including potential use of Inrix data. If advanced, the strategy would also need to develop appropriate message protocols to only alert travelers to the bypass route when viable.
- **Automated DMS Messaging Based on Queue Detection** – The Iowa DOT TMC has the ability to monitor freeways across the Des Moines metro area for current conditions to support detection and management of incidents and breakdowns in traffic. TMC operators are able to post messages to a number of DMS signs throughout the system, but currently the process is manually administered. This strategy would consider the use of automatic monitoring of freeway conditions to alert TMC operators to likely queue conditions and then offer the TMC operator a simple set of responses based on pre-planned decision support.

System Modifications

- **Extend Acceleration/Deceleration Lanes** – This strategy considers the adjustment of striping and potential minor pavement strengthening or gap pavement additions to create better geometry for merge/diverge conditions. Adjustments to acceleration/deceleration lanes can remove a physical constriction to freeway flow through minor shifts that impact existing wide shoulders over a short distance.
  - I-80 west of Southwest mix master – Target elimination of interior merge westbound
  - I-35/I-80 westbound from Northeast mix master to NW 2nd Street – Provide a longer distance over which merges can occur.
  - US Highway 65 to Northeast mix master – Provide a longer distance over which merges can occur and more quickly separate decelerating traffic from mainline vehicles.
  - Merle Hay Road On-Ramps to I-35/I-80 – Target elimination of interior merge eastbound and westbound to shift some merge activity to occur within the ramp.
- **Queue Spillback Mitigation** – Exit ramps represent a location where traffic leaves uninterrupted freeway conditions for the stop-and-go patterns of the arterial system. If demand for the ramp exceed ramp capacity and storage, stopped traffic will end up backing up to the freeway creating high-risk conditions for crashes. This strategy would develop a concept of operations for detection and changes in ramp terminal signal control to discharge ramp queues prior to spilling back to the freeway. Strategy development may also include installation of new ramp sensors as necessary.
  - I-35 Northbound at Oralabor Road
- **Add Exit Option Lanes** – Freeway exit ramps can be served by exit only lanes or option lanes that allow traffic to make a straight or diverging movement from the same lane. The provision of option lanes can alleviate tight ramp weave conditions, but spreading out the

distance over which lane changes are accomplished. This strategy looks at extending auxiliary lanes in one or more locations to improve congestion by re-striping and potential shoulder modifications to provide more functional space for lane changes.

- I-235 Eastbound at Iowa Highway 28/63rd Street Off-Ramp
- I-235 Eastbound at Valley West Drive Off-Ramp

7.5 ICM STRATEGIES SELECTED FOR IMPLEMENTATION

From the strategies described in Section 7.4, the Iowa DOT indicated 16 strategies as shown in Table 6 should be advanced as part of the Des Moines ICM program as funding is identified.

Table 6: ICM Strategies Selected for Funding Consideration

Strategy	Phase 1 Priority	Recommended Next Step
Naming Conventions for System Ramps	High	Implementation Plan
Permit Over-Sized Trucks for Off-Peak Only	High	Implementation Plan
Queue Spillback Mitigation	High	Implementation Plan
Median Barrier Gates	High	Project Level Con Ops
High Impact Corridor Signal Optimization	High	Project Level Con Ops
Add US 65 / Iowa 5 Bypass Travel Time Comparison to Truck Information System	High	Project Level Con Ops
Dynamic Shoulder Lanes / Part-time Shoulder Use	High	Concept Strategy Refinement
Variable Speed Advisories	High	Concept Strategy Refinement
Extend Acceleration / Deceleration Lanes	High	Concept Strategy Refinement
Add Exit Option Lanes	High	Concept Strategy Refinement
Ramp Metering / Adaptive Ramp Metering	High	Concept Strategy Refinement
Investigate Recurring Signal Optimization Program / Dedicated Funding	Medium	Concept Strategy Refinement
Add US 65 / Iowa 5 Bypass to Travel Time Comparison in DMS Messaging	Medium	Not Yet Determined
Build Traffic Signal Inventory Data Portal for Metro Area with Improvement Screening	Medium	Not Yet Determined
Update Communications / Fiber Inventory	Medium	Not Yet Determined

Iowa DOT separated the recommended Phase 1 strategies into high and medium priority strategies though all strategies listed in Table 6 will garner further consideration for implementation as part of the Des Moines ICM program. The 11 high priority projects were then sub divided into groups based on the project management team's recommendation for next steps. These next steps include developing Concept of Operations, Implementation Plans and further refinement. Next steps are dependent on the specific strategy – primarily related to each strategy's level of sophistication and how well operations are understood for each. More sophisticated strategies requiring additional insight on how each should be operated or that have greater involvement from a wider pool of stakeholders were slated for individual Concept of Operations document. Those with more straight forward operations, where one or relatively few stakeholders are involved, were slated for Implementation Plans. It should be noted that the strategies requiring Concept of Operations documents will also be subject to Implementation Plan development. Strategies that require additional data collection or analysis were slotted as "Concept Strategy Refinement." These strategies generally fall outside of the 2-year implementation window of Phase 1 projects. More detailed descriptions of each ICM strategy recommended next steps, as well as the listing of the ICM strategies that fall under each step is provided in the following sections.

7.5.1 Concept of Operations

A number of strategies will be advanced through development of a project specific Concept of Operations documents. The project-specific Concept of Operations documents will build upon the ICM program-level Concept of Operations document (to be developed prior to and as a separate document to the project-level Concept of Operations document) to describe in greater detail how the project will fit within the ICM program and how stakeholders will come together to implement/operate related systems and technologies. Concept of Operations documents will be developed for the following strategies:

- Median Barrier Gates
- High Impact Corridor Signal Optimization
- Add US 65 / Iowa 5 Bypass Travel Time Comparison to Truck Information System

Project-level Concept of Operations is required for these strategies because they require greater institutional coordination and/or because the manner in which they will/should operate needs to be described.

7.5.2 Implementation Plans

Implementation plans will be developed as a next step for six strategies that are recommended for deployment as early winners. The implementation plans will be developed with Iowa DOT and stakeholder champions as appropriate and will define the steps required to implement the strategy and associated cost and on-going management responsibility. Implementation plans will be developed for the following six strategies:

- Naming Conventions for System Ramps
- Permit Over-Sized Trucks for Off-Peak Only
- Queue Spillback Mitigation

- Median Barrier Gates
- Add US 65 / Iowa 5 Bypass Travel Time Comparison to Truck Information System
- Investigate Signal Optimization

7.5.3 Concept Refinement

A number of identified strategies were recommended as high priority, but require further refinement before action can be taken in the near term. The five strategies planned for concept refinement include:

- Dynamic Shoulder Lanes/Part-time shoulder Use
- Variable Speed Advisories
- Extend Acceleration/Deceleration Lanes
- Add Exit Option Lanes
- Ramp Metering/Adaptive Ramp Metering

7.5.4 Medium Priority Strategies

It is anticipated that additional implementation plans will be developed subsequent to the findings of this report. The following five strategies represent anticipated future implementation plans:

- Investigate Recurring Signal Optimization Program/Dedicated Funding
- Add US 65/Iowa 5 Bypass to Travel Time Comparison in DMS Messaging
- Build Traffic Signal Inventory Data Portal for Metro Area with Improvement Screening
- Update Communications/Fiber Inventory

Appendix A: Existing Conditions Analysis

As an initial step in the ICM strategy development process, an existing conditions analysis was started for the transportation system in the study area. The existing conditions assessment will be developed in two phases:

1. Phase One: Existing Conditions (complete)
2. Phase Two: Future Baseline Conditions

The existing conditions assessment is derived from a quantitative analysis of historical traffic data related to safety, mobility, and reliability of the transportation network within the Des Moines ICM study area. Data used in the analysis were made available by the Iowa DOT, and data providers with which the Iowa DOT has agreements. The result of these data analyses are corridor and segment level metrics that may be used to help shape the vision, goals, and objectives of the ICM program, and to measure progress in achieving the goals. The existing conditions assessment also provides a segment-level assessment of performance metrics that do not meet recommended performance thresholds as drafted by the project team and confirmed by the Iowa DOT. The segment-level assessment will also help frame near-term and longer-term strategies. Data were analyzed to develop performance metrics and data visualizations that use patterns to describe the complex conditions of the Des Moines metro area roadway system over the last five years. Independent datasets were collected from the following sources to describe transportation system conditions:

- INRIX – Probe Travel Time/Speed Data – 2013–2017 – Segment-Based Records
- Iowa Crash Analysis Tool (ICAT) – Crash Records – 2013–2017 – Point Records
- Traffic Detector Data – Radar Volumes and Speed – 2016–2017 – Point Records
- Primary Roadway Volumes – Average Daily Traffic Volumes – 2013–2016 – Segment-Based Records
- Advanced Traffic Management System (ATMS) – Traffic Management Center (TMC) Event Data – 2016–2017 – Point Records
- National Weather Service – Temperature, Precipitation, and Visibility Logs – 2008–2017 – Areal records

The application of individual data sources is described in greater detail in the sub-sections pertaining to specific analyses. To make the greatest use of the data collected, relationships were identified between the various datasets. The datasets have not been collected and maintained with consideration of existing relationships amongst the data sources. Most relationships were established based on similarity in time and space. For example, a speed observation on a given freeway segment may be correlated with a crash on the same segment because both occurred within a short distance and time period. The other correlation that was necessary was establishing a reference point where performance metrics could be collected. The geography chosen was the Traffic Message Channel segment, which is a standard used in reporting probe vehicle data collected from INRIX for the study. The choice of working from the Traffic Message Channel segment was based on the ability to directly perform travel time analysis. There are also advantages in applying traffic volume data and other point data to a segment as opposed to the complexity required to extrapolate from the INRIX data to other segment definitions.

The Traffic Message Channel segmentation is made available to the Iowa DOT as part of the National Performance Management Research Data Set (NPMRDS). For this analysis, all segments within a five-county boundary were queried. A total of 1,656 segments were identified, with the segments used for most analyses shown in Figure 7.

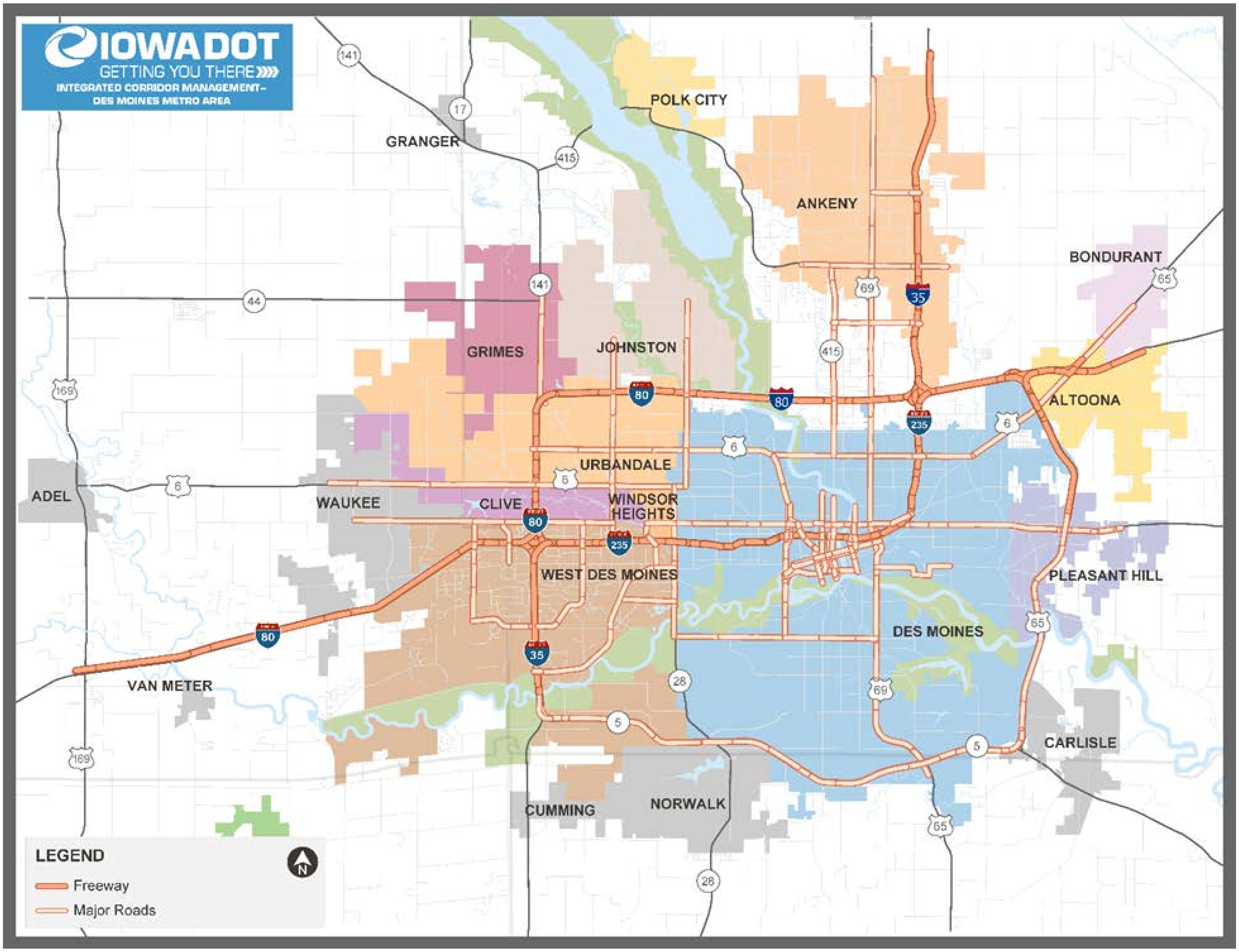


Figure 7: INRIX Segments – Des Moines Metropolitan Area Study Roadways

TRAVEL TIME RELIABILITY ANALYSIS

Travel time reliability describes how congestion varies from day to day, indicating how predictable travel conditions are on a facility. For this study, the primary source of reliability metrics was INRIX speed data provided at the road segment level. As mentioned, the Traffic Message Channel Segment was the geography associated with INRIX speed data. With the lengths of these segments known, travel times can be calculated by dividing the travel speed on a segment by the segment's length. INRIX data were available for calendar years 2013–2017.

Speed Profiles

One method to analyze INRIX speed data is to segregate daily speed profiles by day-of-week and vertically offsetting the profiles to reveal major speed drops, including deviations from the normal daily pattern. Figure 8 shows an example where travelers on Fridays often experienced congestion during the p.m. peak hour (sharp dips in the speed curves) in 2017. To a lesser extent, non-recurring p.m. congestion can be seen on other weekdays throughout the year. In addition, other isolated non-recurring congestion events, such as the ones circled in red (**O**) in Figure 8, can be seen throughout the year. These types of diagrams can also be used to visually correlate congestion with its causes.

Figure 9 shows annual speed profiles for both directions on segments of three different study-area freeways in 2017: I-235, I-35, and I-80 – illustrating the variety of reliability conditions found in the study area.

The I-235 segment experienced recurring congestion during both peak periods in the eastbound direction, with similar but less pronounced patterns in the westbound direction. The I-35 segment experienced occasional congestion at various times of day in both directions, but perhaps nothing that could be identified as a pattern. The I-80 segment experienced regular and significant congestion during the p.m. peak period in the eastbound direction, but less pronounced patterns in the westbound direction.

Speed Trends

The annual speed profiles can also be used to identify study area trends. Figure 10 illustrates profiles for a selected segment of I-235 between 2013 and 2017. These 44,000+ data points demonstrate how this segment evolved from experiencing occasional weekday congestion in 2013 to frequent, significant, recurring weekday congestion by 2017. Similar increasing congestion trends are evident throughout the study area, as further described later in this document.

Travel Time Distributions

As mentioned, the INRIX speed data can be converted to travel times when segment lengths are known. The travel times on each segment, over a long period (on the order of at least a year), can be aggregated into a distribution. When viewed in a cumulative curve, this distribution creates a reliability “signature.” This curve can be standardized by dividing the travel time by the free flow travel time, creating a metric known as the Travel Time Index (TTI). The cumulative TTI curve allows comparison between facilities of different length. As shown in Figure 11 – the less reliable a facility, the more the curve, sometimes referred to as a Cumulative Distribution Function (CDF), “leans forward.”

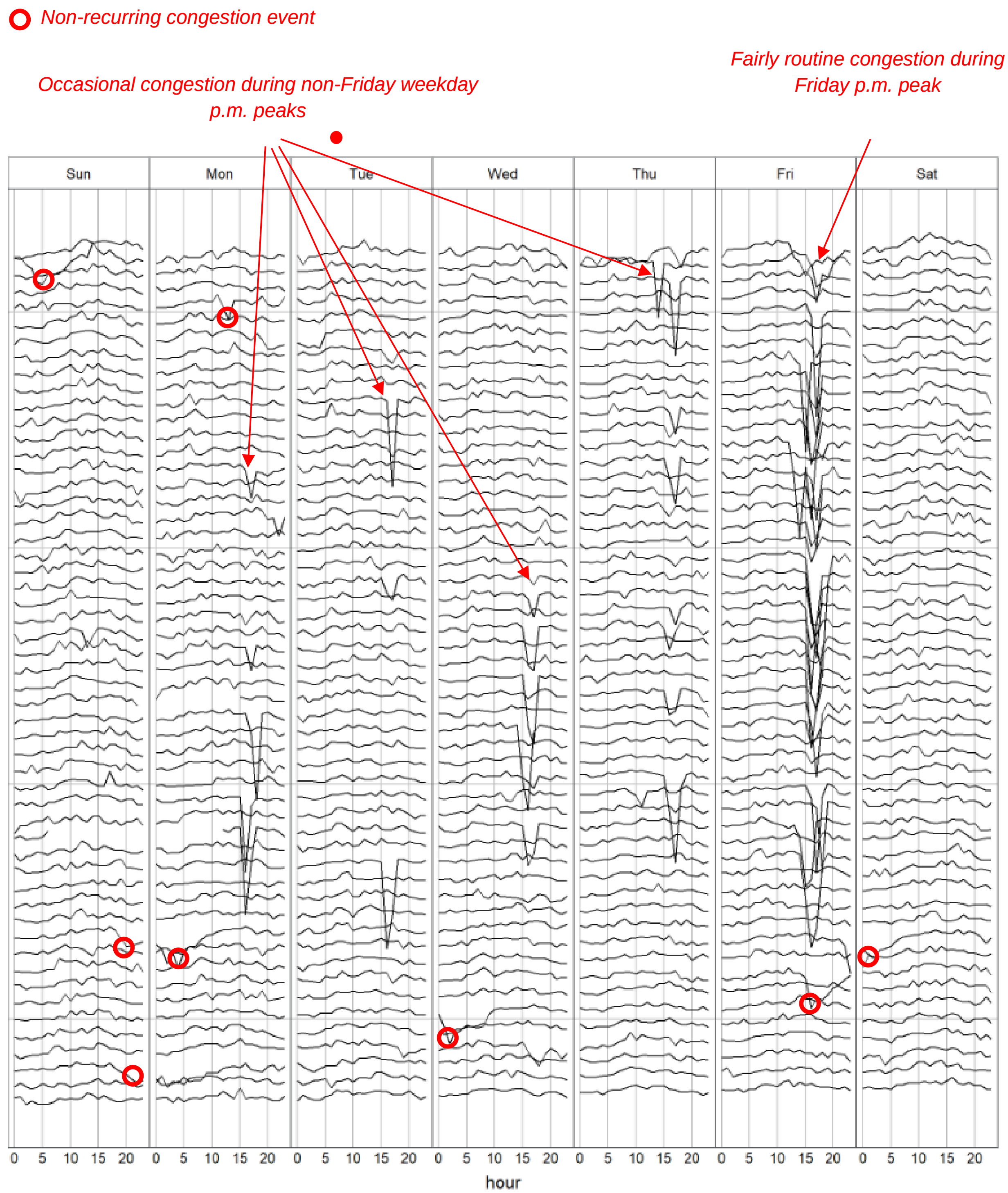


Figure 8: Offset Daily Speed Profiles (Example), I-80 East of I-35 (TMC 118+04613), 2017

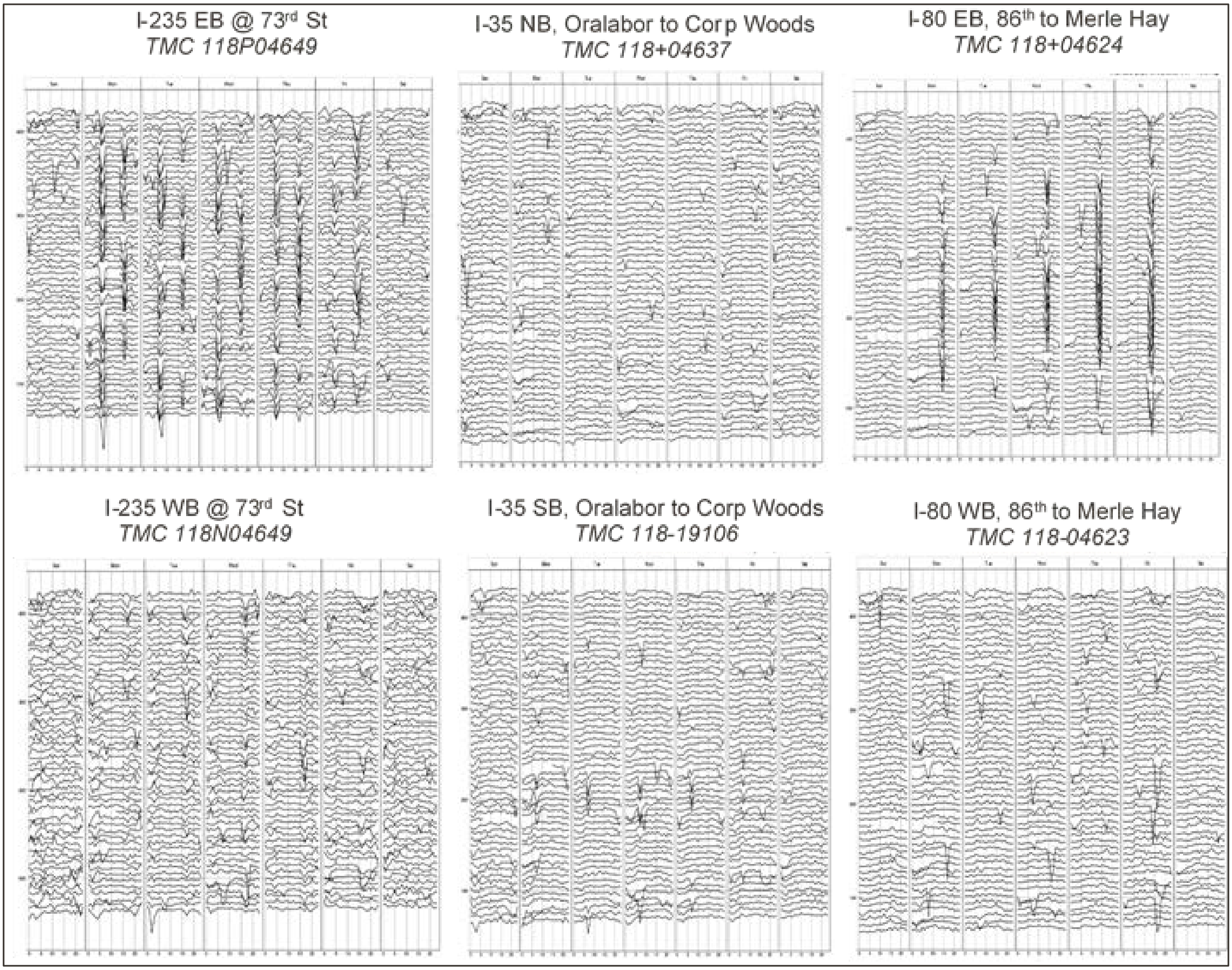


Figure 9: Daily Speed Profiles, Three Selected Locations, 2017

Figure 12 shows example CDFs for eight selected TMCs (four freeways, four arterials) over the entire 5-year study period, arranged in a progression from more reliable to less reliable. Each graph shows 24 CDFs, one for each hour of the day. Note that six key (typical peak) hours (7–9 a.m. and 3–7 p.m.) are shown in red. Note that the arterial curves, even at their most reliable, tend to lean forward more than freeways due to more frequent interruptions on arterials (signals, cross-traffic, etc.).

The CDFs are shown alongside 5-year hourly speed profiles for each segment. Note that the arterials speed profiles exhibit a downward trend, seen on many freeway and non-freeway segments throughout the study hour. This trend is discussed further later in this document.

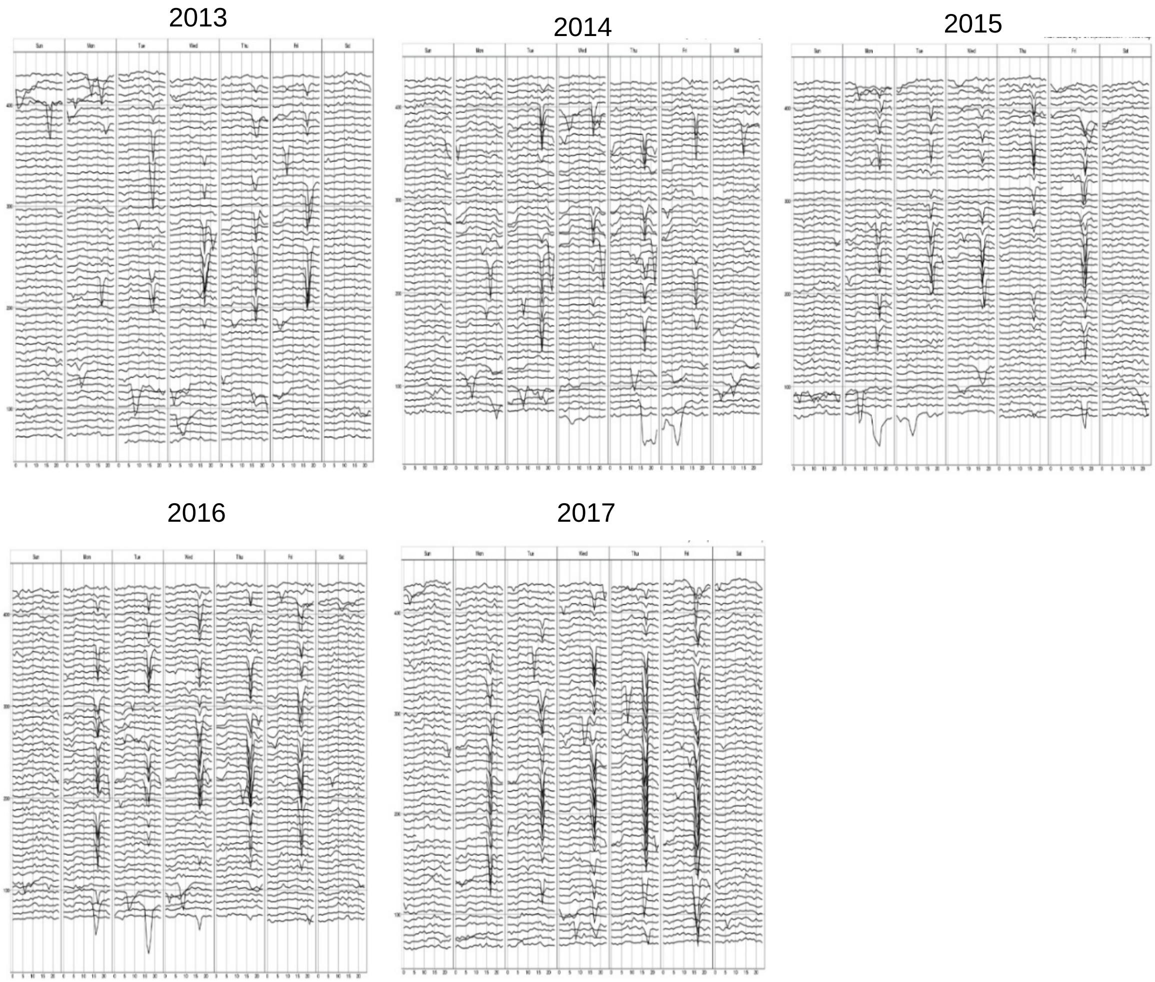


Figure 10: Example Annual Trend – Daily Speed Profiles, I-235 EB @ 73rd St (TMC 118P4649), 2013-2017

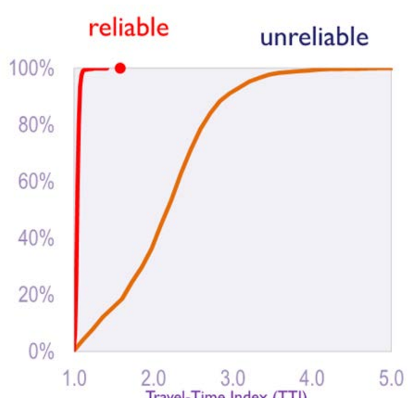


Figure 11: Example Cumulative Travel Time Index Curves

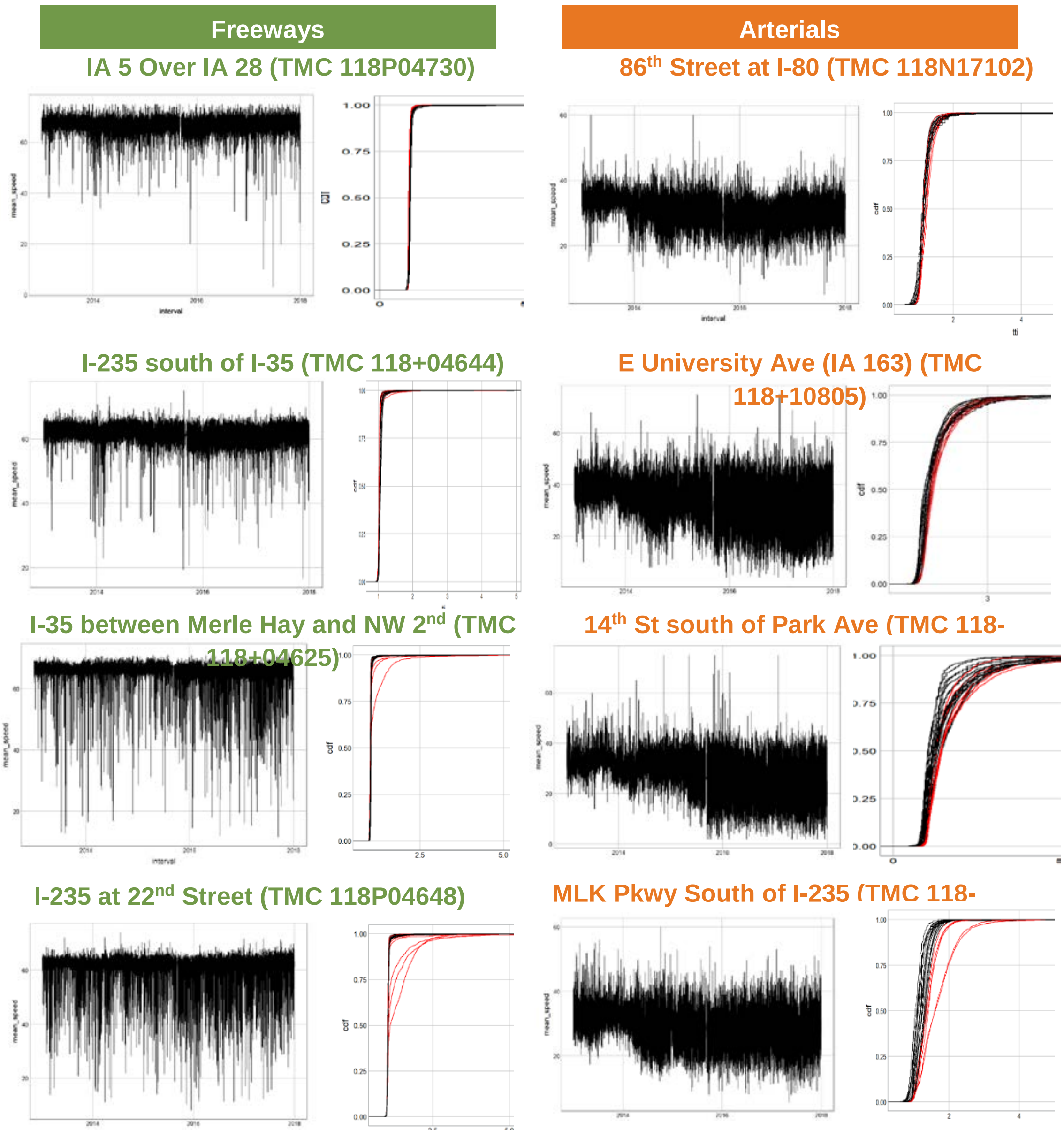


Figure 12: Cumulative TTI Distributions (CDFs) and Time-Series Speed Profiles for Selected TMCs (Note: Red curves denote the six key hours described in the text)

Reliability Metrics

Because reliability is a concept reflecting the variability of travel times, it is difficult to characterize it with a single metric. Multiple measures help focus understanding of reliability. A breakdown of reasonable reliability metrics to explore for this study follows:

Many reliability metrics are extractable from the travel time distribution. These metrics attempt to characterize the shape of the distribution with a single number.

- **Mean Travel Time Index (TTI):** The average travel time one would expect on a given segment of highway at a specific time of day over the entire year. One drawback of this index is that the mean value can't fully convey the shape and extremes of the TTI distribution. For example, a facility with a very high number of moderately congested days could exhibit the same Mean TTI as a facility with equal numbers of uncongested and highly congested days.

- **Planning Time Index (PTI):** Per the Federal Transit Administration (FTA), the planning time index represents "the total travel time that should be planned when an adequate buffer time is included." The PTI compares near-worst case travel time to a travel time in light or free-flow traffic. For example, a planning time index of 1.60 means that for a 15-minute trip in light traffic the total time that should be planned for the trip is 24 minutes (15 minutes × 1.60 = 24 minutes). The PTI is useful because it can be directly compared to the TTI (a measure of average congestion) on similar numeric scales, as in Figure 13. The PTI is computed as the 95th percentile travel time divided by the free-flow travel time." PTI is a better measure than TTI for conveying reliability because it represents the extreme of the travel time distribution, which is a more stable predictor due to the typical shape of the cumulative TTI curve.
- **Level of Travel Time Reliability (LOTTR):** This measure was recently adopted by the USDOT as part of the MAP-21 and FAST legislation. LOTTR is defined as the ratio of the longer travel times (80th percentile) to a "normal" travel time (50th percentile). For this study, to keep consistent with the calculation of other measures, LOTTR is calculated slightly different than the FHWA measure—it is evaluated for the six one-hour periods previously described (as opposed to 15-minute periods between 6 a.m. and 8 p.m.), and is based on vehicle miles as opposed to person miles.
- **Semi-Variance:** Although calculating the variance about the mean is common statistical practice, this is not necessarily the most relevant metric for the TTI, which by definition can't be less than 1.0. Therefore, the concept of the semi-variance (σr) has been used. Statistically, this quantity describes how travel times vary from the ideal (TTI=1.0) rather than the average. The semi-variance curve is constructed from the cumulative TTI curve by calculating (TTI - 1)2 for each percentile (p), the difference between TTI(p) and the vertical line y = 1, and then squaring that difference. The sum of these values is the shaded area shown in Figure 14.

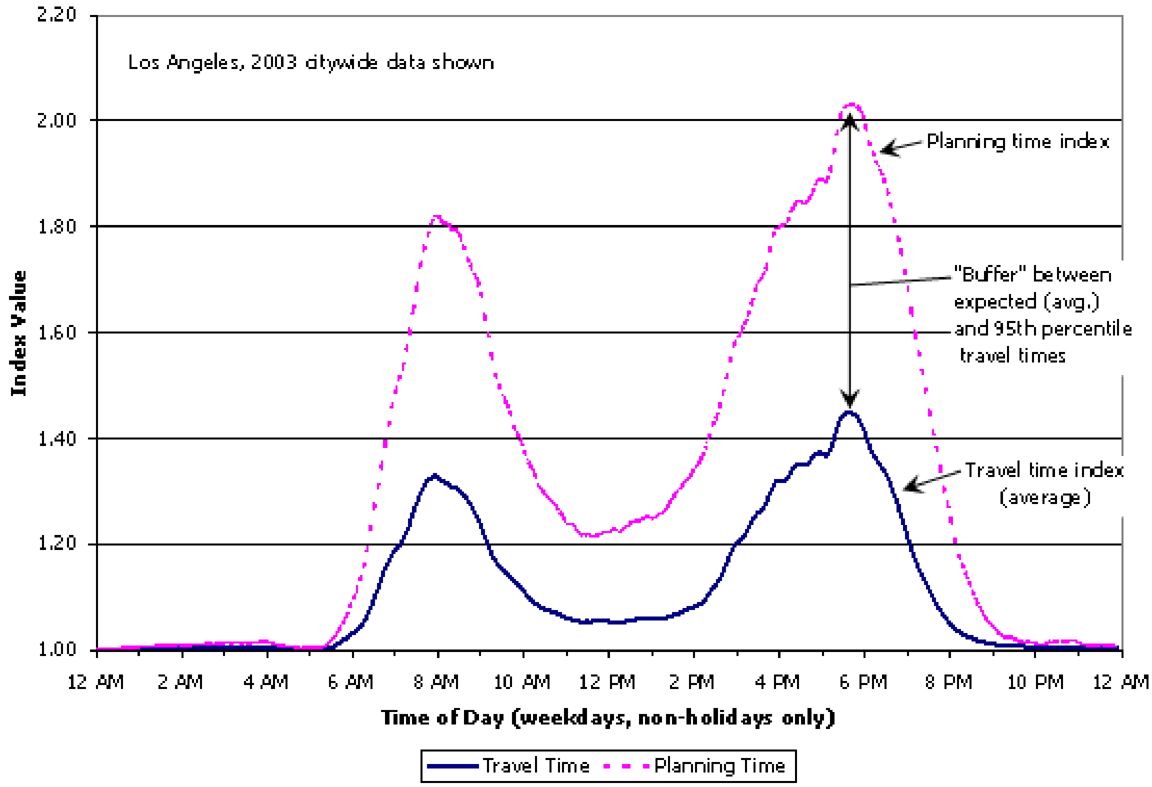


Figure 13: Illustration of Travel Time Index and Planning Time Index

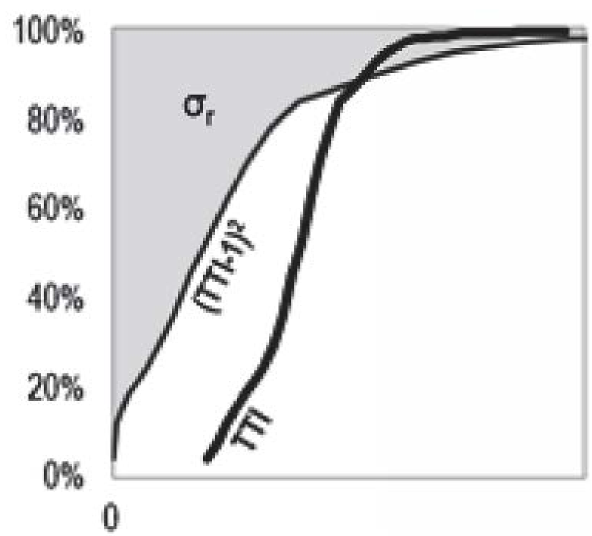


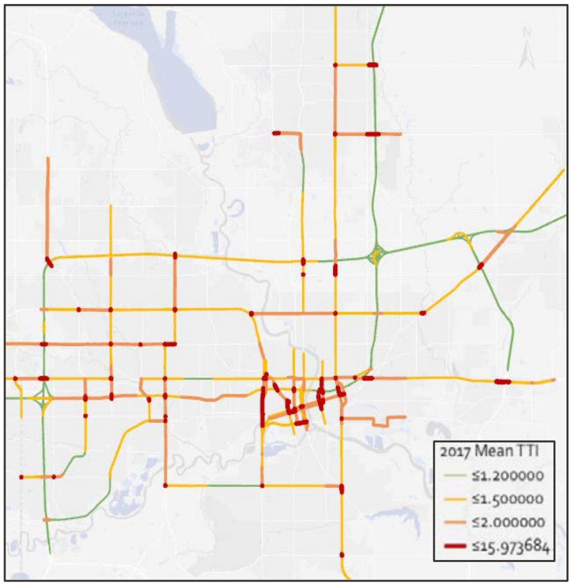
Figure 14: Illustration of Semi-Variance

Iowa DOT's performance management committee has expressed that the PTI is a preferred reliability metric for the department. While multiple metrics have been reported for their various strengths, added emphasis will be given to the PTI as the study progresses.

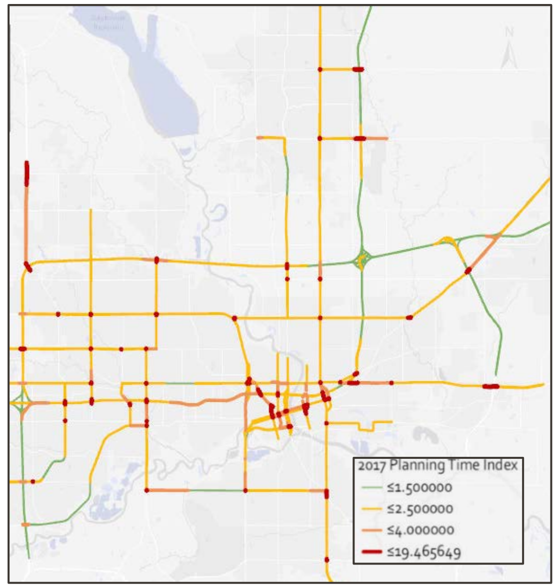
For each study roadway segment, the above metrics were calculated for each of the six key study hours (7–9 a.m., 3–7 p.m.). Figure 15 maps these metrics over the study area for 2017, showing the worst of these six hours for each segment (*Traffic Message Channel Segment*). For the purposes of this study, segments are used as indicators of reliability rather than corridors (which would require further aggregation). Based on these maps, the following are key findings related to existing reliability conditions in the study area:

- Not apparent from Figure 15 is the important fact that reliability has been decreasing in the study area over time. This trend is discussed further later in this document.
- Short segments showing highly unreliable conditions (what look like red "dots" on the maps) are artifacts of the data collection methodology and should not be considered meaningful.
- I-235 between the southwest junction of I-35/I-80 and downtown Des Moines appears to be among the most unreliable corridors in the study area. Close to downtown, this appears to be a westbound p.m. peak period phenomenon that is in effect for up to two hours each weekday. Near I-80, both the westbound and eastbound directions experience unreliability during both peak periods, but the eastbound issue (which affects traffic for as many as three hours on weekdays) begins to abate around 63rd Street, tapering to fairly tame levels by 43rd Street.
- I-35/80 between Highway 141 and 2nd Street exhibits a high level of unreliability during the p.m. peak hour in the eastbound direction. This issue largely affects a single hour. South of Highway 141, unreliability affects both directions I-35/I-80 as far south as the southwest junction of I-35/I-80/I-235. In the northbound direction, this generally is evident in the p.m. peak periods with a few exceptions. In the southbound direction, it appears to affect both peak periods.
- Martin Luther King Jr. Parkway, from I-235 to the Raccoon River, exhibits unreliability in both directions, for at least two hours southbound and up to three hours northbound.
- Route 141 north of I-80/I-35 (as far north as East 1st Street in Grimes) experiences unreliability in the northbound direction for 2 hours during the p.m. peak. It also experiences unreliability in the southbound direction for one hour during the a.m. peak period. To a lesser extent, several other hours experience unreliability in the southbound direction. This segment transitions from uninterrupted flow at both ends to interrupted flow in the middle, and the reliability issues are likely related to the relatively more frequent stops required in this section because of several large signalized intersections.
- Other segments that experience reliability issues potentially worth investigating include:
    - Hickman Road near I-35/I-80
    - Fleur Drive/Martin Luther King Jr. Parkway between I-235 and Park Avenue
    - University Avenue approaching Hubbell Avenue from both directions

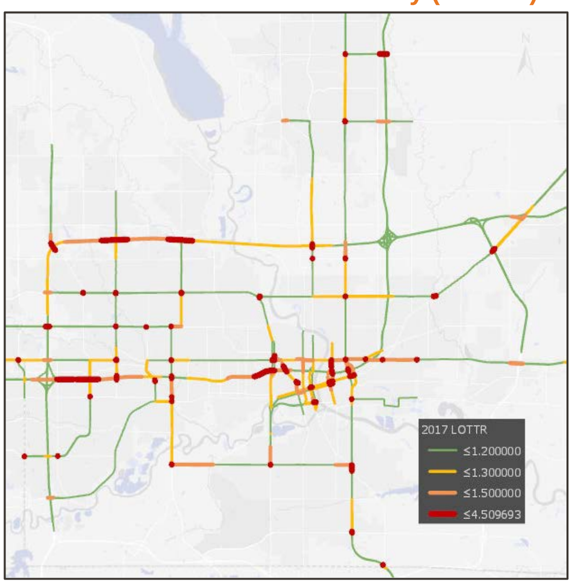
Mean Travel Time Index (TTI)



Planning Time Index (PTI)



Level of Travel Time Reliability (LOTTR)



Semi-Variance

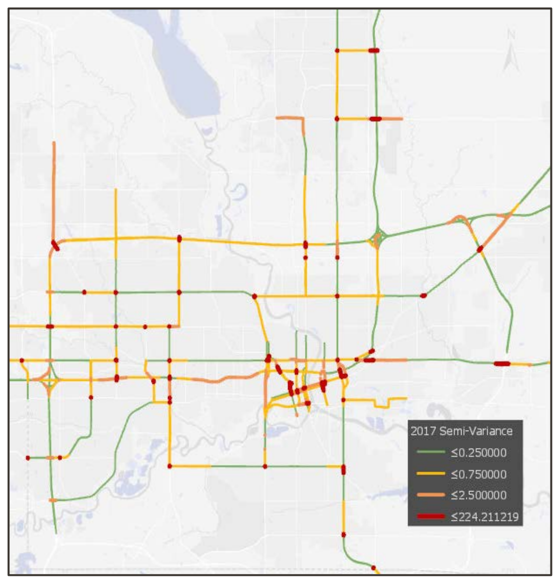


Figure 15: CDF-Derived Reliability Metrics – 2017, Worst Hour

Overall Reliability Trends

Figure 16 aggregates some of the reliability measures over the entire study area described above. These aggregations are artificially contrived and do not carry statistical meaning, but they do give an indication of trends. PTI, TTI, and LOTTR all show varying degrees of increase between 2013 and 2016, with a leveling off in 2017. In investigating these trends over time, the project team reviewed the Inrix provided confidence scores between 2013 and 2017. Confidence score is the primary attribute available for determining the data coverage and how reflective the data is of real-time conditions. Median confidence scores remain at a level above 90 percent for all five years, likely because the study corridors of interest exhibit higher traffic volumes and travel time information subscribers then typical of the state of Iowa as a whole.

These trends, or something like them, could be useful for illustrating the broader area-wide effects of potential ICM strategies. Further work may be done in subsequent phases of the project to numerically refine the way these measures are aggregated, to understand how these aggregations might relate to acceptability thresholds, and to generally hone the area-wide analysis.

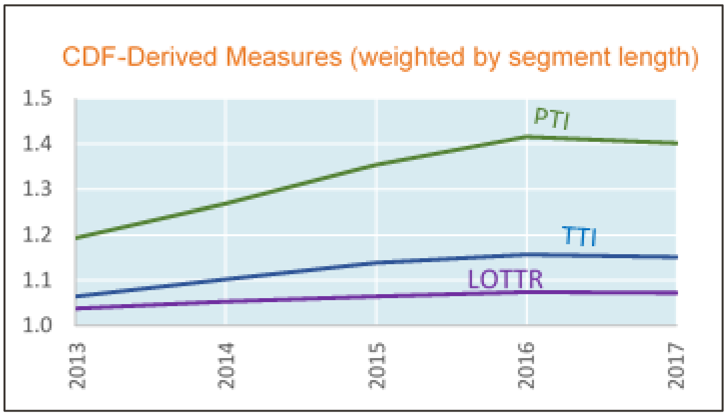


Figure 16: Aggregate Reliability Metrics Trend (2013-2017)

MOBILITY ANALYSIS

Mobility represents the efficiency with which the transportation system moves people and goods. Similar to travel time reliability, efficiency for the analysis of mobility looks at travel times as a key performance measure, where excessive travel times are termed congestion. Additionally, mobility analysis also looks at several key proxies for congestion: volume-to-capacity ratio level of service (LOS) and segment density-based LOS. Mobility was analyzed for congestion using multiple methods and also ascribed some impacts of mobility to sources of recurring and non-recurring congestion as shown in Figure 17.

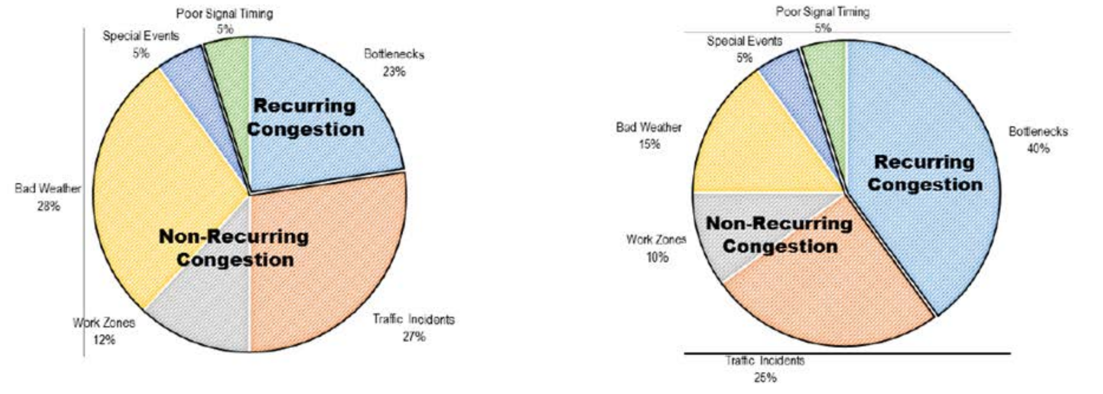


FIGURE 1. IOWA SOURCES OF CONGESTION, 2013-2015

FIGURE 2. NATIONAL SOURCES OF TRAFFIC CONGESTION, 2005 (Cambridge Systematics, 2005)

Figure 17: Sources of Congestion (Source: Iowa DOT TSMO Plan)

Recurring Congestion – Bottlenecks

If typical peak period traffic volumes are above what can usually be sustained on a given freeway, traffic can regularly be slowed through the corridor or even backup in stop-and-go conditions. In many cases this imbalance of demand to available capacity can represent a bottleneck as the capacity of one freeway section reduces the amount of traffic that can be carried compared to upstream freeway segments. As seen from Figure 18, nationally these bottlenecks or constrictions along the freeway are responsible for about 40 percent of all congestion, and in Iowa the number is lower at 23 percent of all congestion.

The analysis considered recurring congestion for the freeway portion of the study area looking for potential bottlenecks on the Des Moines metro freeway system. The review of recurring congestion considered two methods in addition to the prior documented travel time analysis: Hours of Congestion and Volume Screening Method.

Hours of Congestion

The Hours of Congestion measure examines the number of hours per year during which the speed on a given segment dips below a certain value. The congestion calculation differs for freeways and arterials:

- Freeways - Congestion is defined as speeds less than 45 mph.
- Arterials - Congestion is defined as speeds less than 60 percent of the free-flow speed (FFS). FFS is calculated as the 90th percentile of annual speeds on the segment.

Figure 18 illustrates this metric for both 2013 and 2017. Large growth in congested hours over that period appear to be evident when comparing the two figures. It is unclear whether the low congestion values in 2013 are truly reflective of congestion at that time, or an artifact of measurement.

2013 **2017**

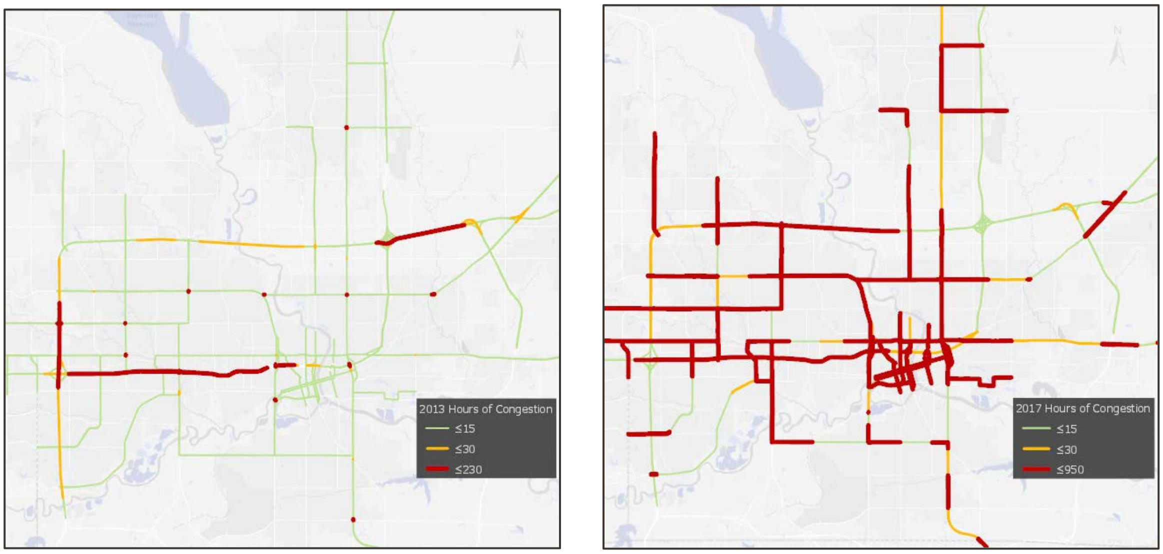


Figure 18: Hours of Congestion, 2013 and 2017

Figure 19 aggregates the hours of congestion measure over the entire study area. The aggregation is intended to give an indication of trends. The hours of congestion show a degree of increase between 2013 and 2016, with a leveling off in 2017, and an outlier in 2014.

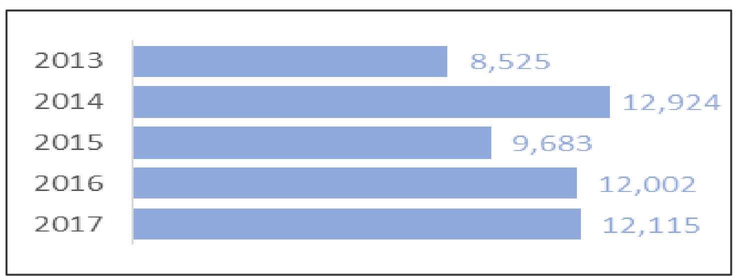


Figure 19: Study Area Hours of Congestion Trend, 2013-2017

Volume Screening Method

Volume screening in traffic operations analysis is a simplified approach to compare the volume of traffic on a segment versus a simplified set of parameters describing traffic supply, typically just the number of travel lanes.

Volume screening methods are extremely common in high-level planning including travel demand modeling to focus the scope of further analysis to just segments with unsatisfactory operating conditions. This analysis used a common volume screening method—Florida DOT's 2013 Quality Level of Service (QLOS) Handbook. Note the volume against which screening should be performed is the overall segment demand, which may not be well represented by the count of vehicles if speeds are low enough to limit volumes reaching the count station.

The Iowa DOT maintains permanent Intelligent Transportation System equipment in the state's metropolitan areas to monitor traffic conditions. The Des Moines Metropolitan Area freeway system includes 106 permanent traffic sensors with 97 side fire radar detection, eight automatic traffic recorders, and one weigh-in-motion. See Figure 20 for traffic sensor coverage.

Freeway traffic sensors provide a source of data that allows for analysis of traffic volumes continuously over several years. In this study, the period of 2016 and 2017 was used for recurring congestion volume screening as this data was available in an existing database and aligned with other source congestion data. The traffic volumes represent mainline freeway conditions at hourly flow rates every minute. The existing database correlated to the primary freeway study area resulted in 109 directional segments with observed volumes.

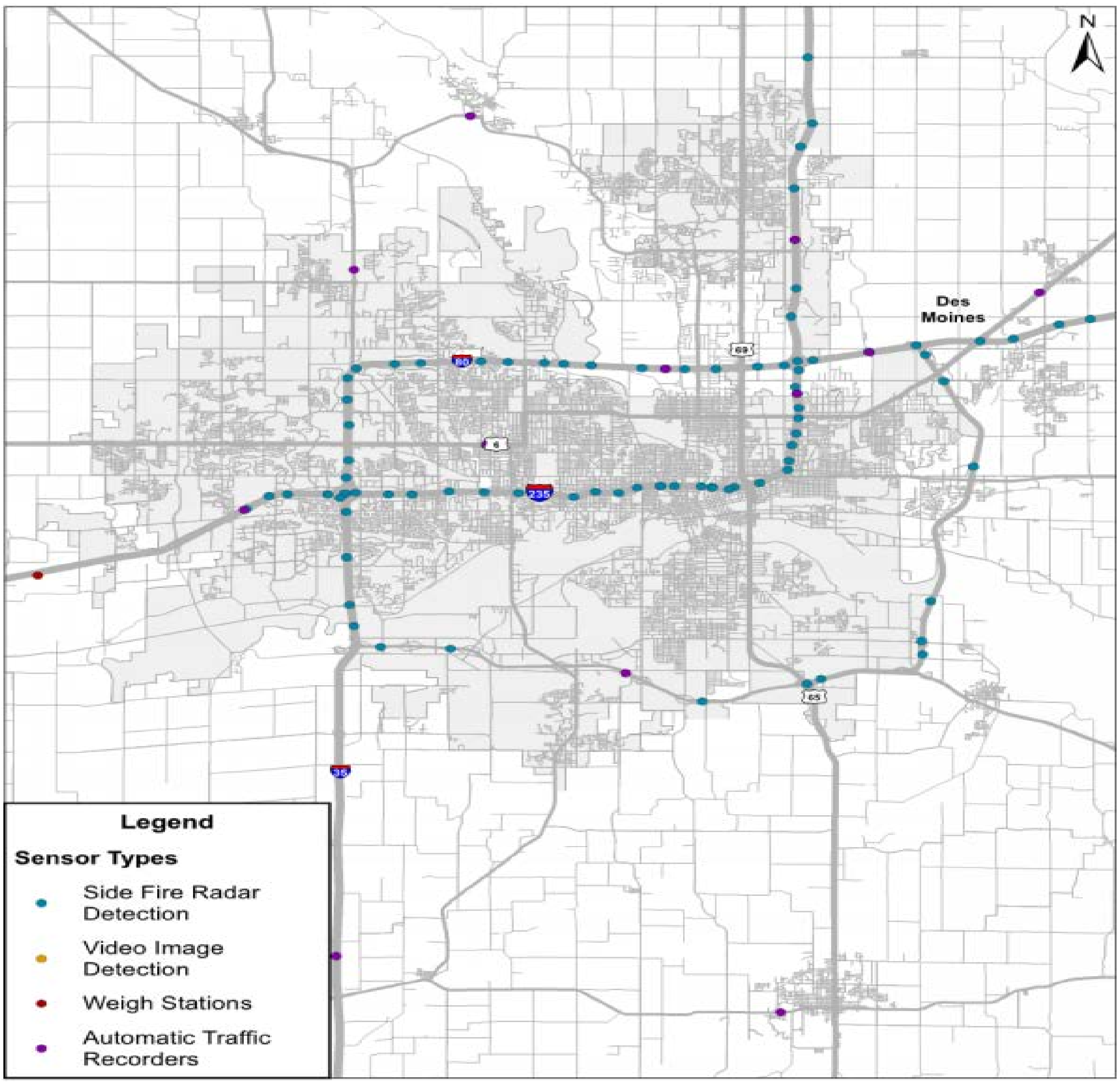


Figure 20: Traffic Sensor Coverage (Iowa DOT ITS & Communications Service Layer)

The traffic sensor volume data was combined with other study area data to tie volume readings to network segment geometry characteristics. The network geometry file used was the INRIX Traffic Message Channel Segment file described previously. The base segment file was reviewed to confirm at each sensor location the number of freeway lanes in each direction and the presence of an auxiliary lane between ramps.

Hourly traffic volumes were then aggregated and compared to service volume lookup tables in the 2013 QLOS Handbook to determine the LOS from A to F, which is defined by the Highway Capacity Manual. Figure 21 shows the service volume table relating traffic volumes, LOS, and geometry. Figure 22 describes the operating characteristics typical of each LOS letter grade.

UNINTERRUPTED FLOW FACILITIES

FREEWAYS

Lanes	B	C	D	E
2	2,260	3,020	3,660	3,940
3	3,360	4,580	5,500	6,080
4	4,500	6,080	7,320	8,220
5	5,660	7,680	9,220	10,360
6	7,900	10,320	12,060	12,500

Freeway Adjustments

Auxiliary Lane	Ramp Metering
+ 1,000	+ 5%

Figure 21: Service Volume Table

Level of Service	Traffic Flow Characteristics
A	Free flow, insignificant delays.
B	Stable operation, minimal delays.
C	Stable operation, acceptable delays.
D	Restricted flow, regular delays.
E	Maximum capacity, extended delays. Volumes at or near capacity. Long queues form upstream from intersection.
F	Forced flow, excessive delays. Represents jammed conditions. Intersection operates below capacity with low volumes. Queues may block upstream intersections.

Source: Highway Capacity Manual 2010

Figure 22: Level of Service Descriptions

The automated process of checking flow rates hourly by sensor and by direction over 2 years yielded a large data set of observations with LOS grades. The project team used LOS to analyze reliability, but for recurring congestion analysis the most important performance measure was worst case LOS by segment. After reviewing the LOS data comprehensively, the analysis was modified to define the worst case LOS by segment as the LOS not exceeded by 95 percent of observations to avoid biasing the LOS grades by a small fraction of the observations that at many sensors showed a large degree of variability. Based on that criteria, the breakdown of LOS occurred as shown in Figure 23.

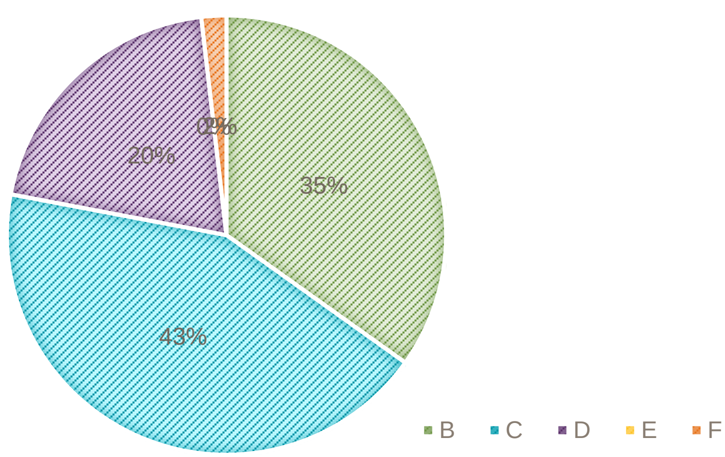


Figure 23: Worst-Case Level of Service Breakdown – Relative Proportion of Segments

Just over 22 percent of the freeway system operates at LOS D or worse, which is traditionally a threshold for needed improvements. The remaining 78 percent of the system does not currently reach LOS D based on a volume screening approach, but may still exhibit characteristics of recurring congestion because of lower useful traffic supply/capacity based on more complex operating characteristics. Segments in this category may still be flagged as needs based on the results of other analyses.

Table 7 lists and Figure 24 shows the segments within the project area that have an LOS of D or worse.

Table 7: Location Descriptions of Fair or Poor Rated Segments

Traffic Message Change Segment	Location Description	LOS
118+04620	I-35 / I-80 NB - University Ave to Hickman Rd (US 6)	D
118N04621	I-35 / I-80 SB - Under Douglas Ave	
118P04622	I-35 / I-80 NB - IA 141 b/w ramps	
118N04652	I-235 WB - Under 42nd St	
118P04652	I-235 EB - Under 42nd St	
118+04661	I-235 EB - E 6th St to US 69 (E 14th / 15th Street)	
118N04660	I-235 WB - E 6th St b/w ramps	
118P04660	I-235 EB - E 6th St b/w ramps	
118N04625	I-35 / I-80 SB - Over IA 415 (NW 2nd St)	
118N04642	I-235 SB - Over Guthrie Ave	
118P04642	I-235 NB - Over Guthrie Ave	
118P04663	I-235 NB - Over Easton Blvd	
118N04644	I-235 SB - Over NEMM	
118P04643	I-235 NB - Euclid Ave b/w Ramps	
118+04644	I-235 NB - Euclid Ave to NEMM	
118-04646	I-235 WB - Valley West Dr to 50th Street	D
118-04624	I-35 / I-80 WB - NW Beaver Creek	
118-04654	I-235 WB - MLK to 31st St	
118-04649	I-235 WB - IA 28 (63rd St) to 73rd St	
118-04650	I-235 WB - 56th St to IA 28 (63rd St)	
118-04614	I-80 WB – Exit 143 (1st Ave N) to US 6 (Hubbell Ave)	
118-19106	I-35 SB - Oralabor Rd to Corporate Woods Dr	
118P04612	I-80 EB - Core of NEMM	F

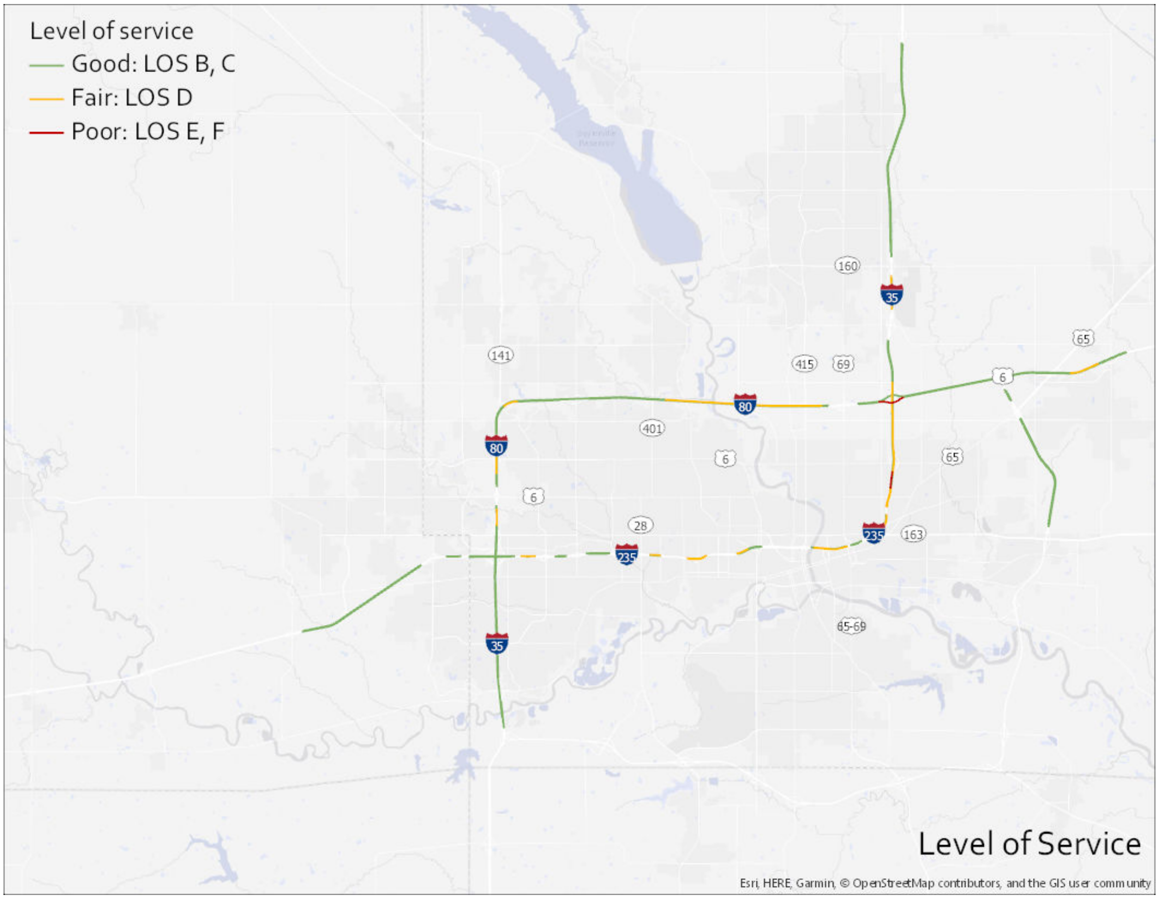


Figure 24: 2016-2017 Worst-Case Peak Hour Level of Service at Sensor Locations [Gaps Represent Segments Not Observed by Sensors]

Weather

Weather can contribute to congestion in two ways: by slowing traffic down due to pavement conditions and/or reduced visibility, and via weather-related crashes and incidents.

For this study, weather data was obtained from the National Weather Service (NWS) for the Des Moines International Airport for the 5-year study period (2013–2017). The data was grouped in ranges defined by the Highway Capacity Manual as shown in Table 8, to be useful for capacity analyses in subsequent phases of the project.

Table 8: Weather

Rain (inches / hr)	
Medium	> 0.15 – 0.25
Heavy	> 0.25
Snow (inches / hr)	
Light	> 0.00 – 0.05
Light-Medium	> 0.05 – 0.10
Medium-Heavy	> 0.10 – 0.50
Heavy	> 0.50
Visibility (miles)	
Minimal	< 0.25
Very Low	0.25 – 0.49
Low	0.50 – 0.99
Temperature (°F)	
Severe Cold	< –4

Figure 25 summarizes the weather data for year 2017. Note that rain events include freezing rain and visibility issues appeared to occur mainly between late fall and early spring.

These weather values are planned to be integrated with the incident analyses described in the following section as part of a future task.

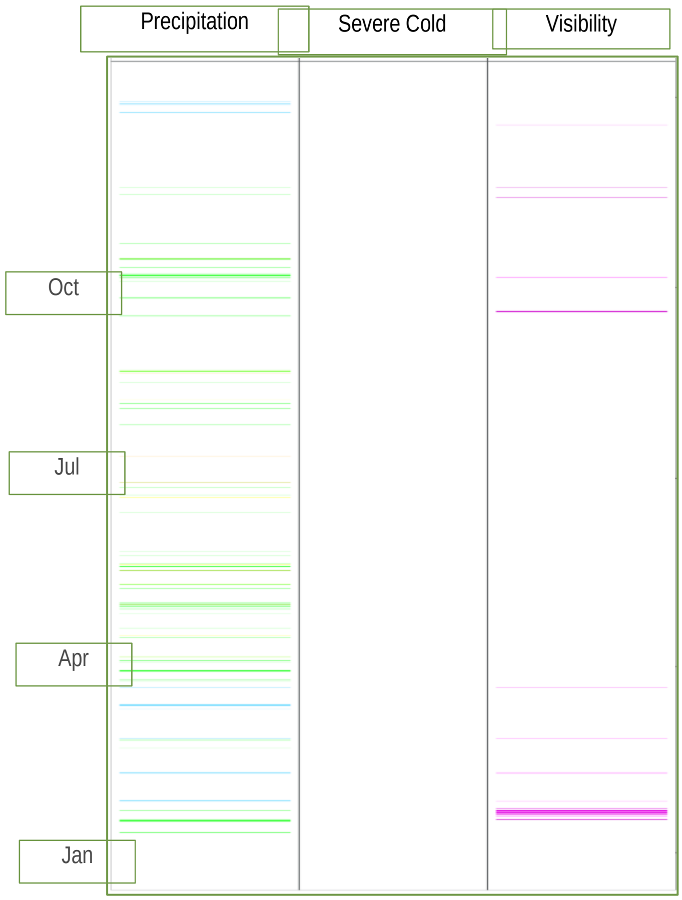


Figure 25: 2017 Weather History, Des Moines Airport

Incident Analysis

The Iowa DOT operates a statewide traffic management center (TMC) that monitors and responds to traffic events along the primary roadway system, including within the Des Moines metro area. The TMC records events captured through monitoring CCTV cameras, emergency service responses, road weather information systems (RWIS), and Iowa's Highway Helper (roadside assist) including key data for analysis such as date of event, time the incident was first observed, time of clearance, details on the level of impact to the roadway, and location coordinates of incidents. The TMC's database also captures information on construction and maintenance activities to capture any work zone traffic impacts. The TMC database has collected information in this historical database format since mid-year 2015, and the data used in this study focused on 2016 and 2017 in the following five categories:

- Construction
- Crash
- Incident (non-crash)
- Weather (Weather data will be further analyzed in future efforts using NWS data)
- None – Slow traffic observed, but no source event (four prior categories) observed

The TMC event database was analyzed at both a corridor level (corridor name specified in the data used directly) and a segment level (spatial join of the data to the INRIX TMC shapes). Both focused on a specific direction of travel. The corridor-level analysis is qualitative, examining overlays of the various sources of congestion and reflecting on visual patterns. The segment-level analysis is quantitative, yet relies on simplifying assumptions described below.

Corridor-Level

Visual Scan of Figure 26 through Figure 37

- Data across all corridors indicates higher levels of observed events in 2017 versus 2016.
- By far the most commonly occurring event is construction. Construction events are primarily shown as occurring overnight, which poses a lower potential for impacts to traveler mobility and lower levels of vehicle exposure in the area of crash activity.
- I-80 in 2017 was the only corridor with extensive daytime construction (on-going March to October). The corridor method does not specifically identify where the construction activities took place, or if the work zone led to significant delays, but segment analysis will allow deeper investigation.
- I-235 shows clear peak period increase in crashes and incidents, a pattern that also is more defined in the last six months of 2017. I-80 shows a peaking effect for corridor crashes in the morning peak period westbound and afternoon peak period eastbound in 2017. The effect on Interstate 80 seems lower in the winter months of the year.
- All three corridors show a heavy scatter of non-crash incidents, but I-35 seems to have fewer crashes than I-80 or I-235, likely attributed to lower system length included and lower traffic volumes.

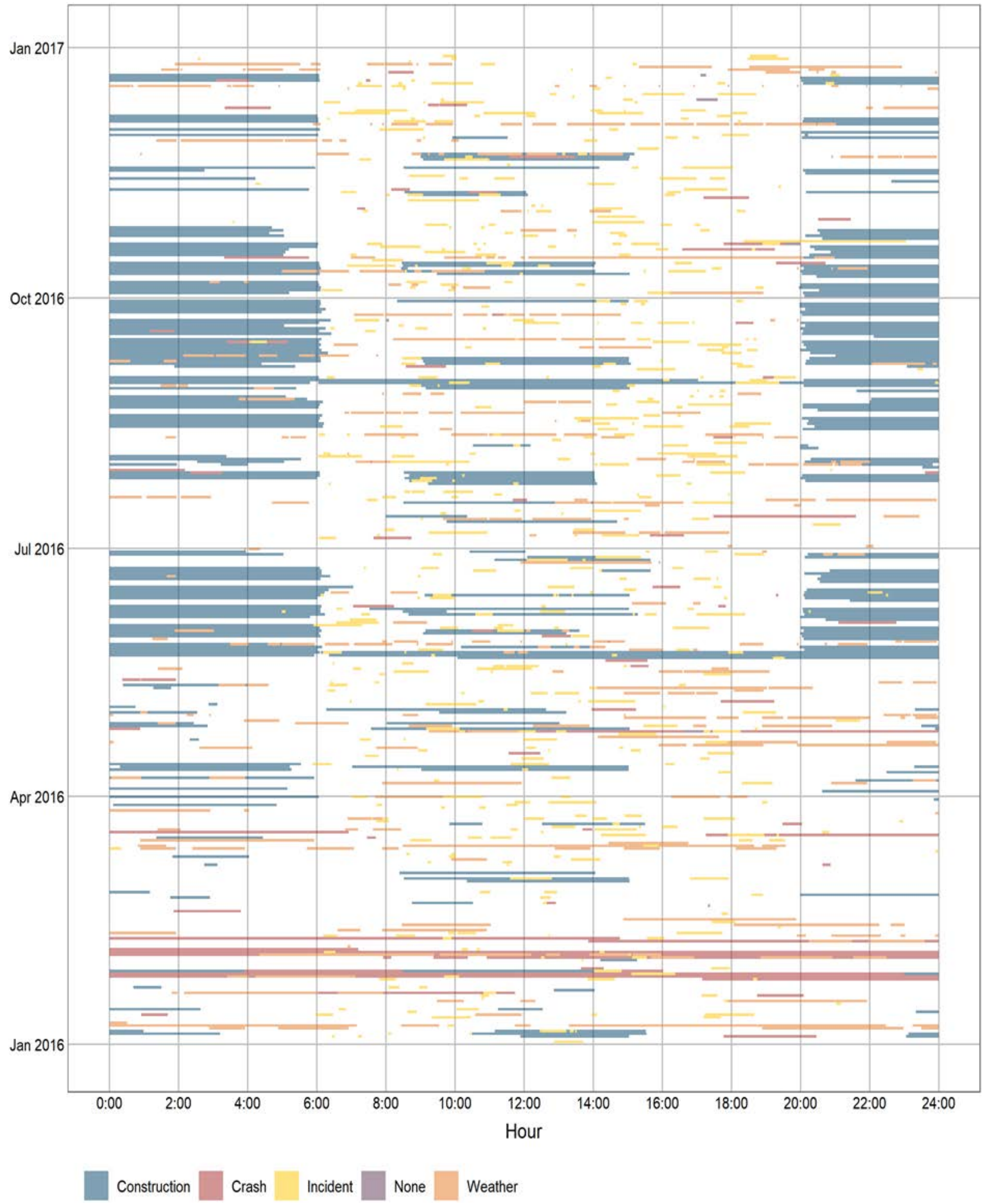


Figure 26: 2016 I-35 Northbound

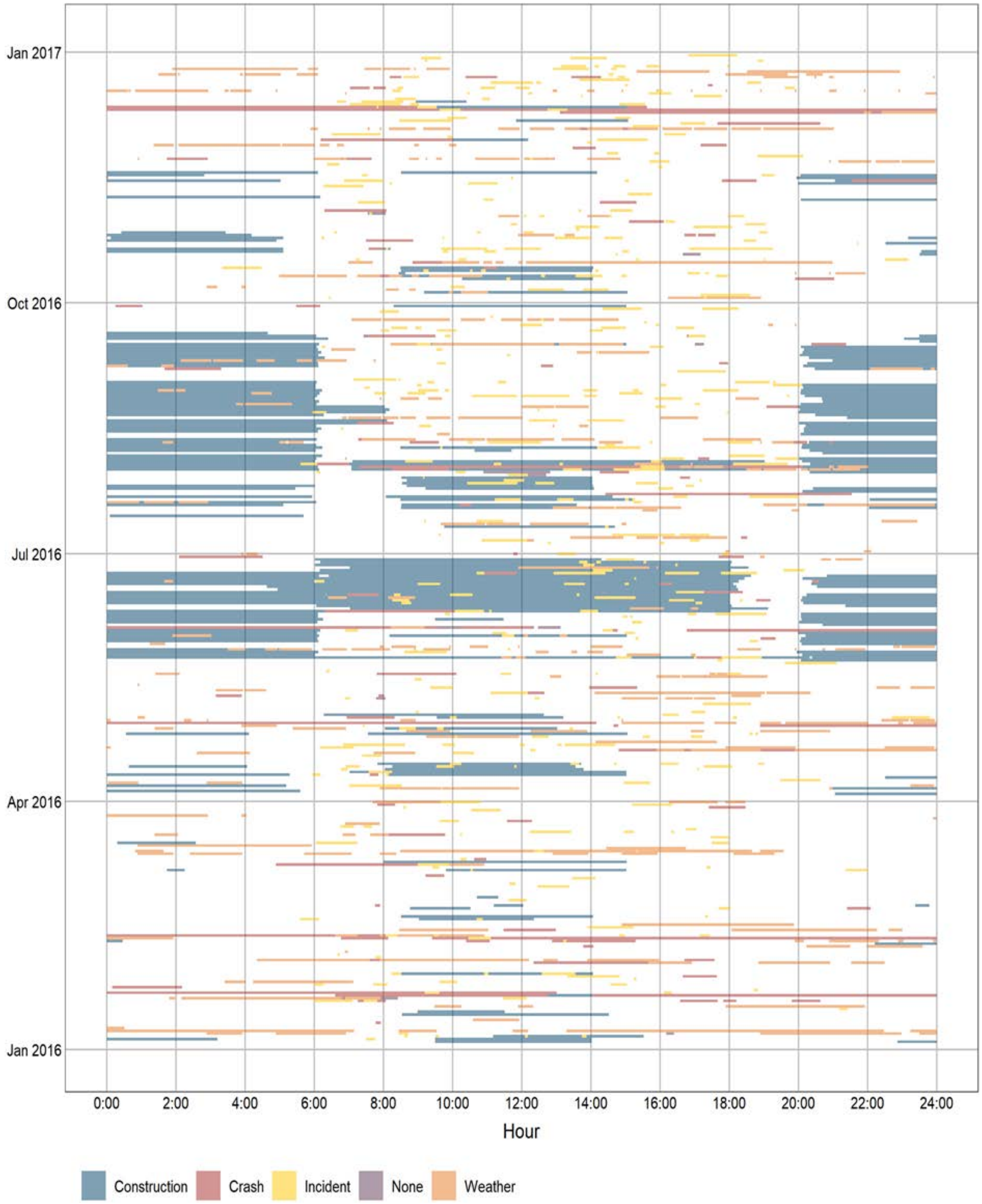


Figure 27: 2016 I-35 Southbound

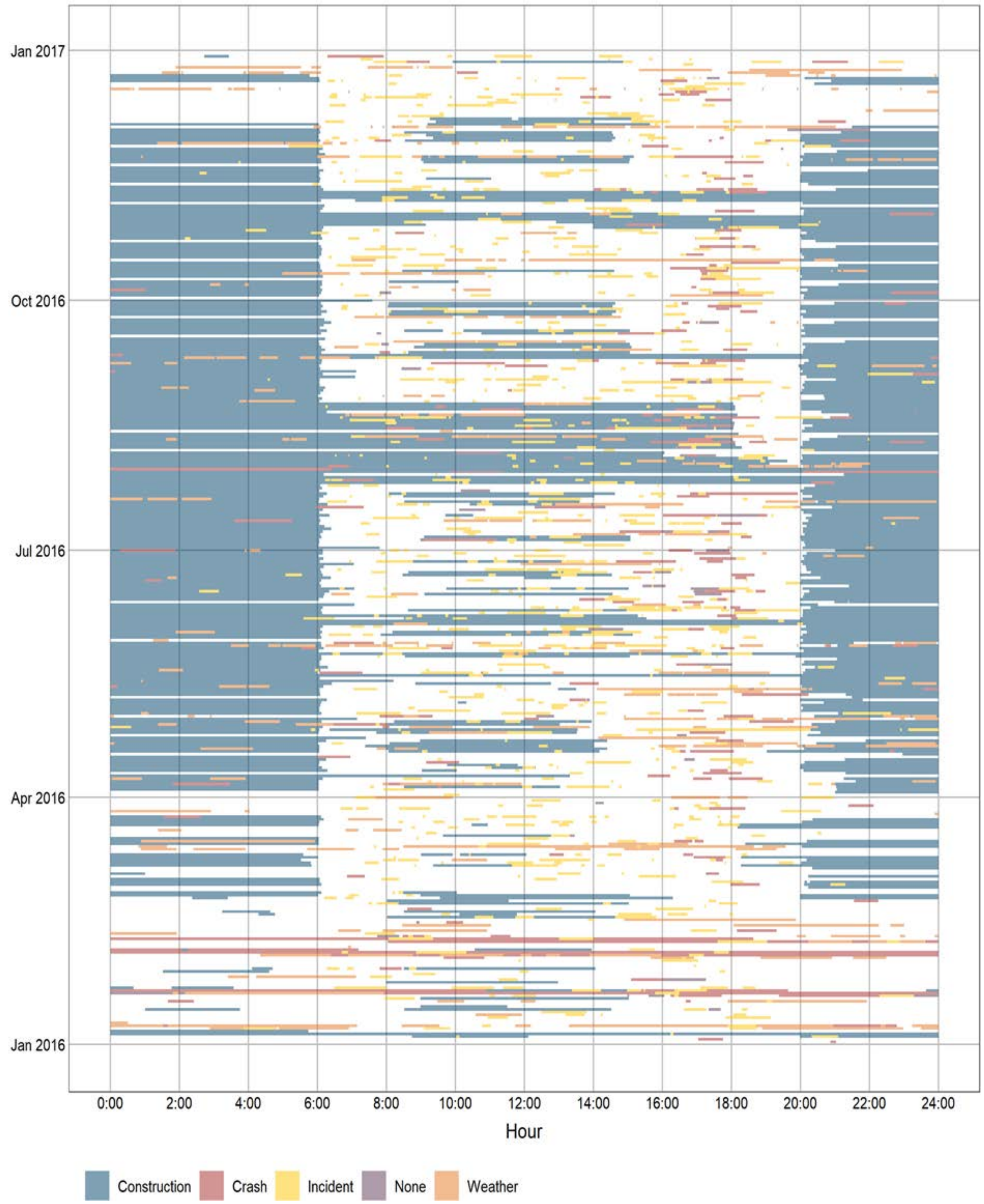


Figure 28: 2016 I-80 Eastbound

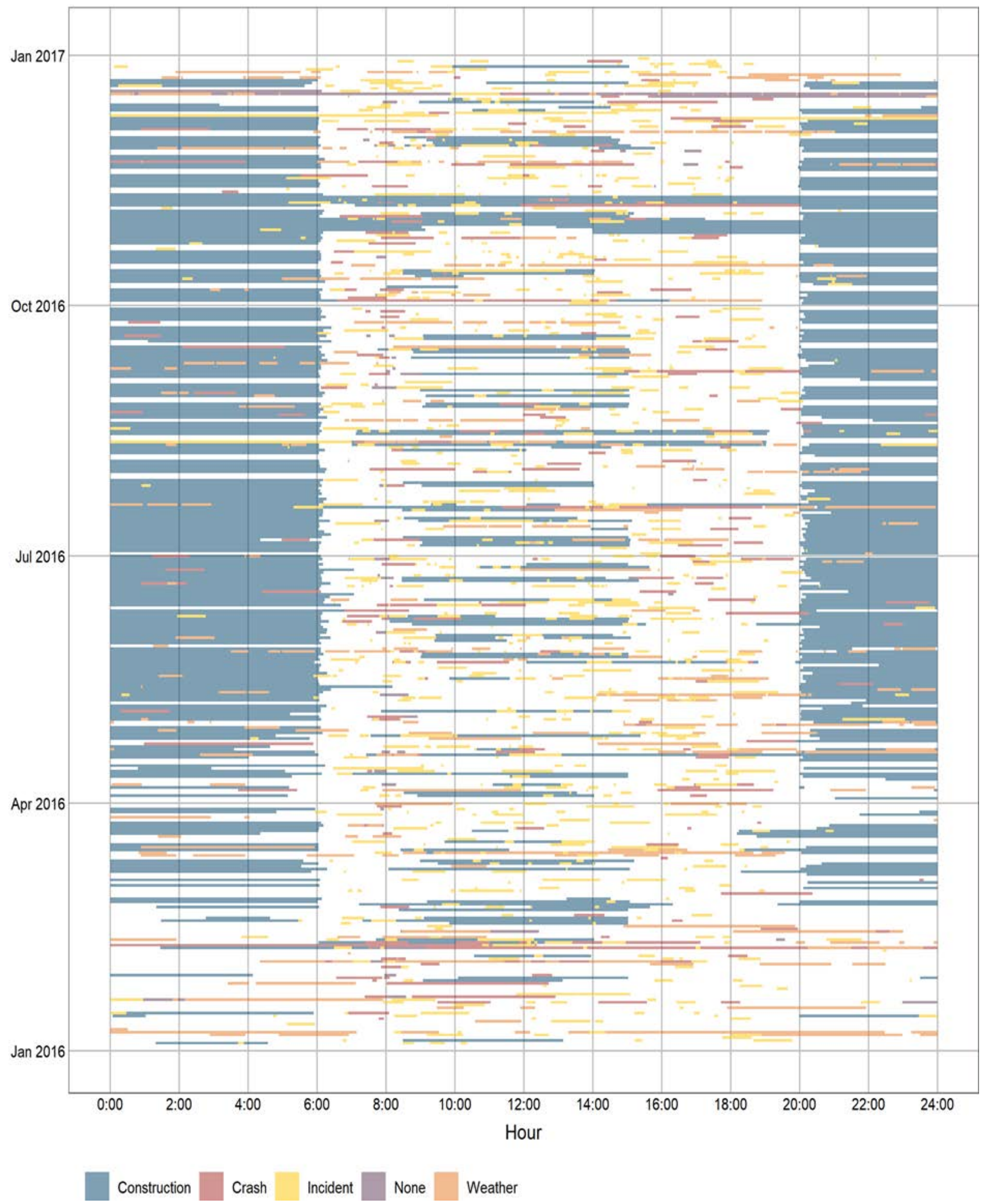


Figure 29: 2016 I-80 Westbound

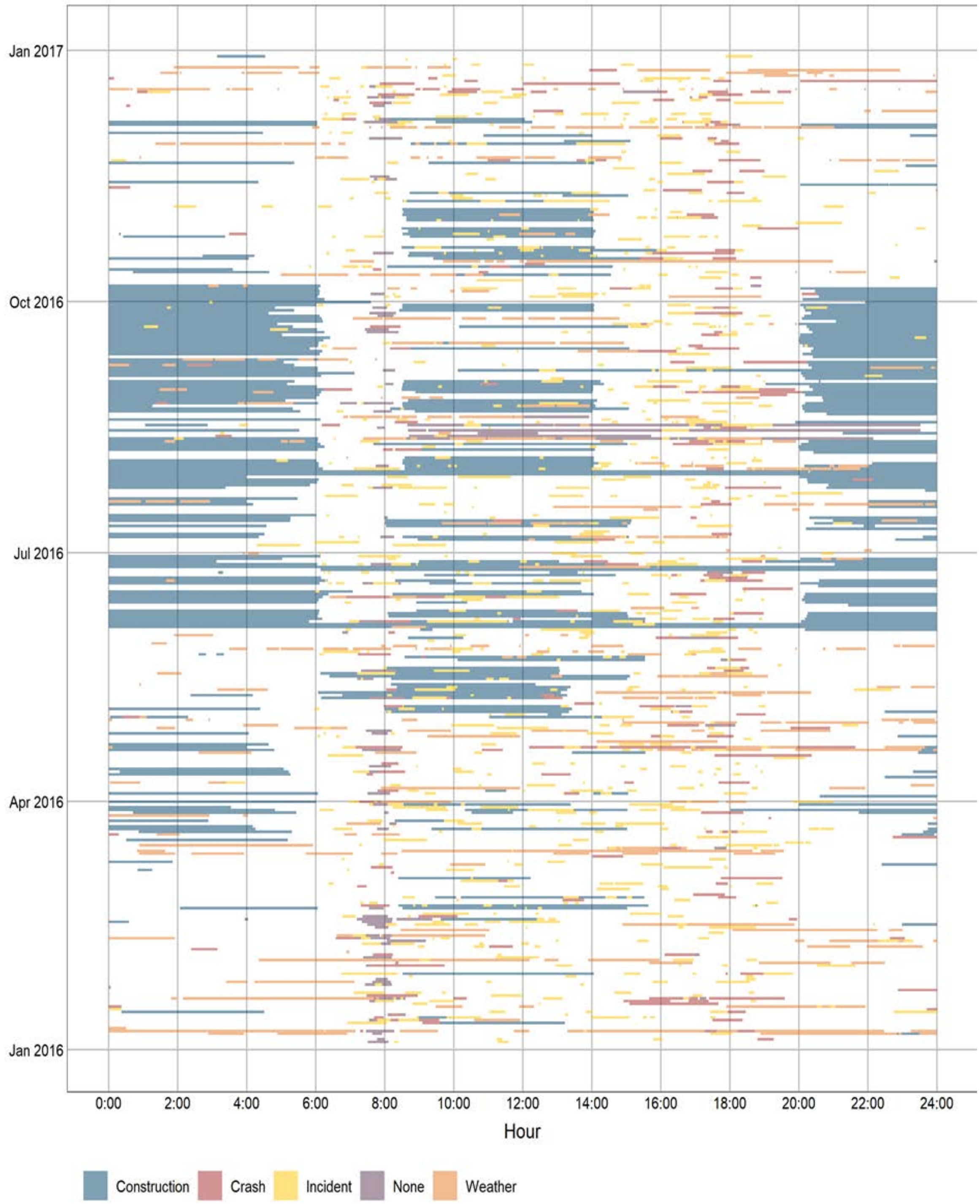


Figure 30: 2016 I-235 Eastbound

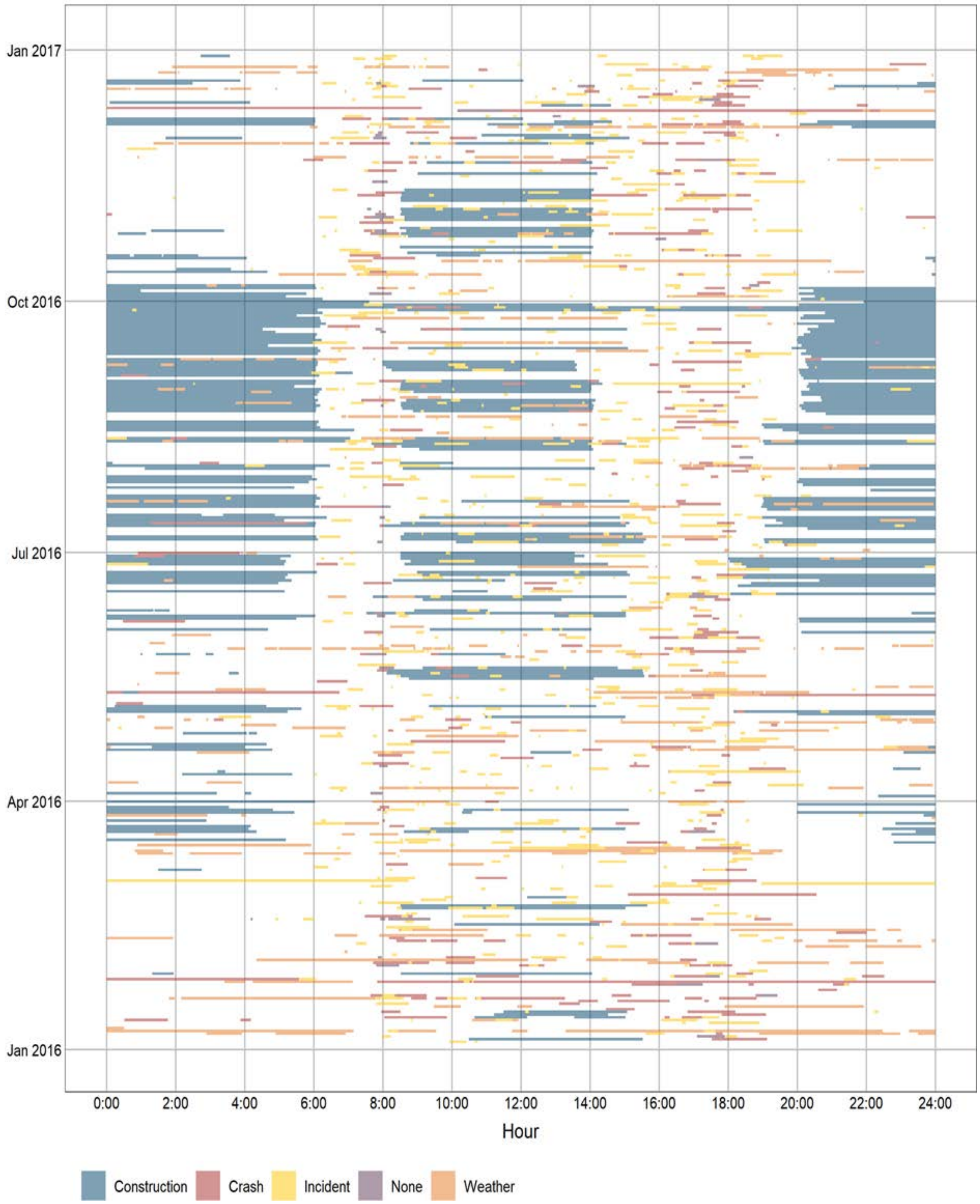


Figure 31: 2016 I-235 Westbound

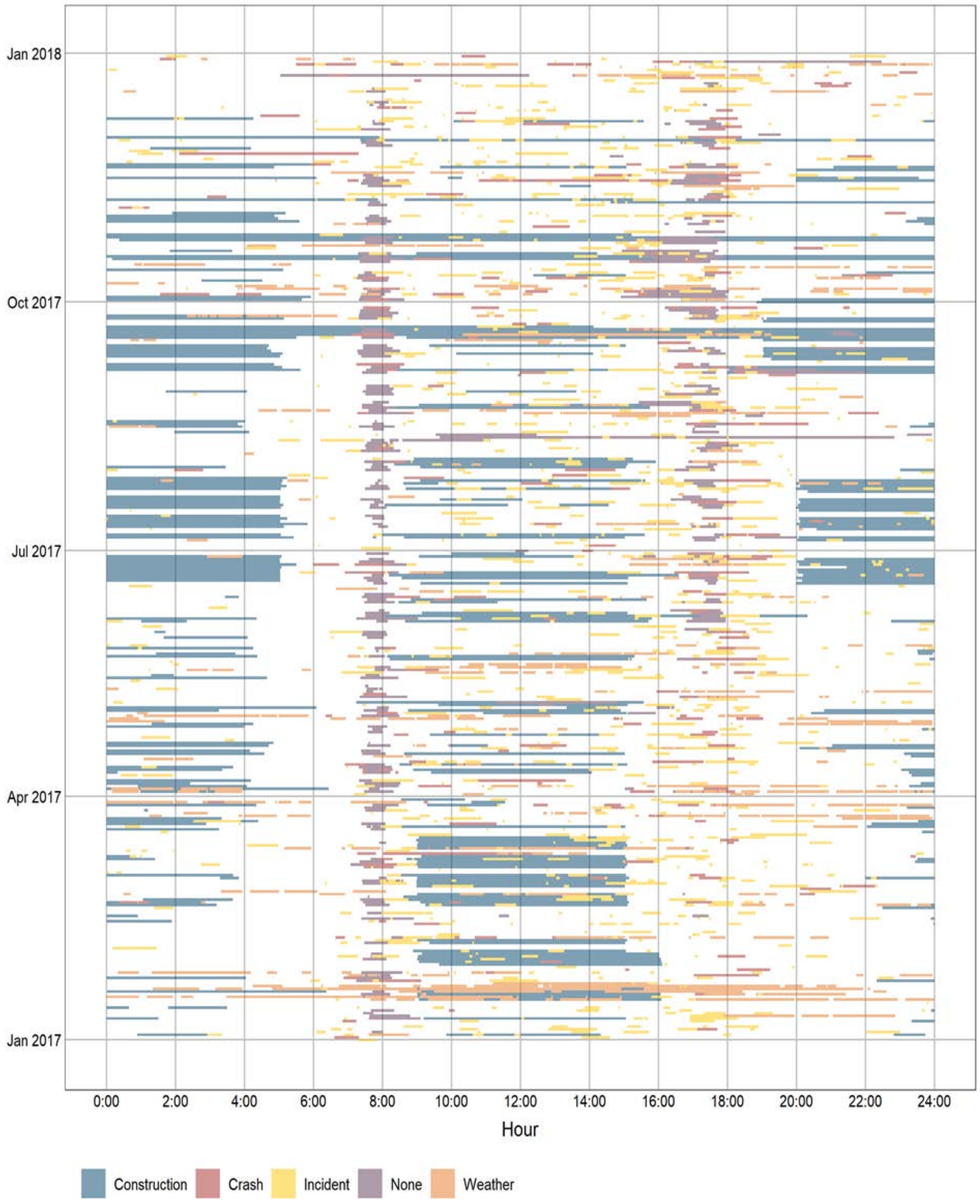


Figure 32: 2017 I-235 Eastbound

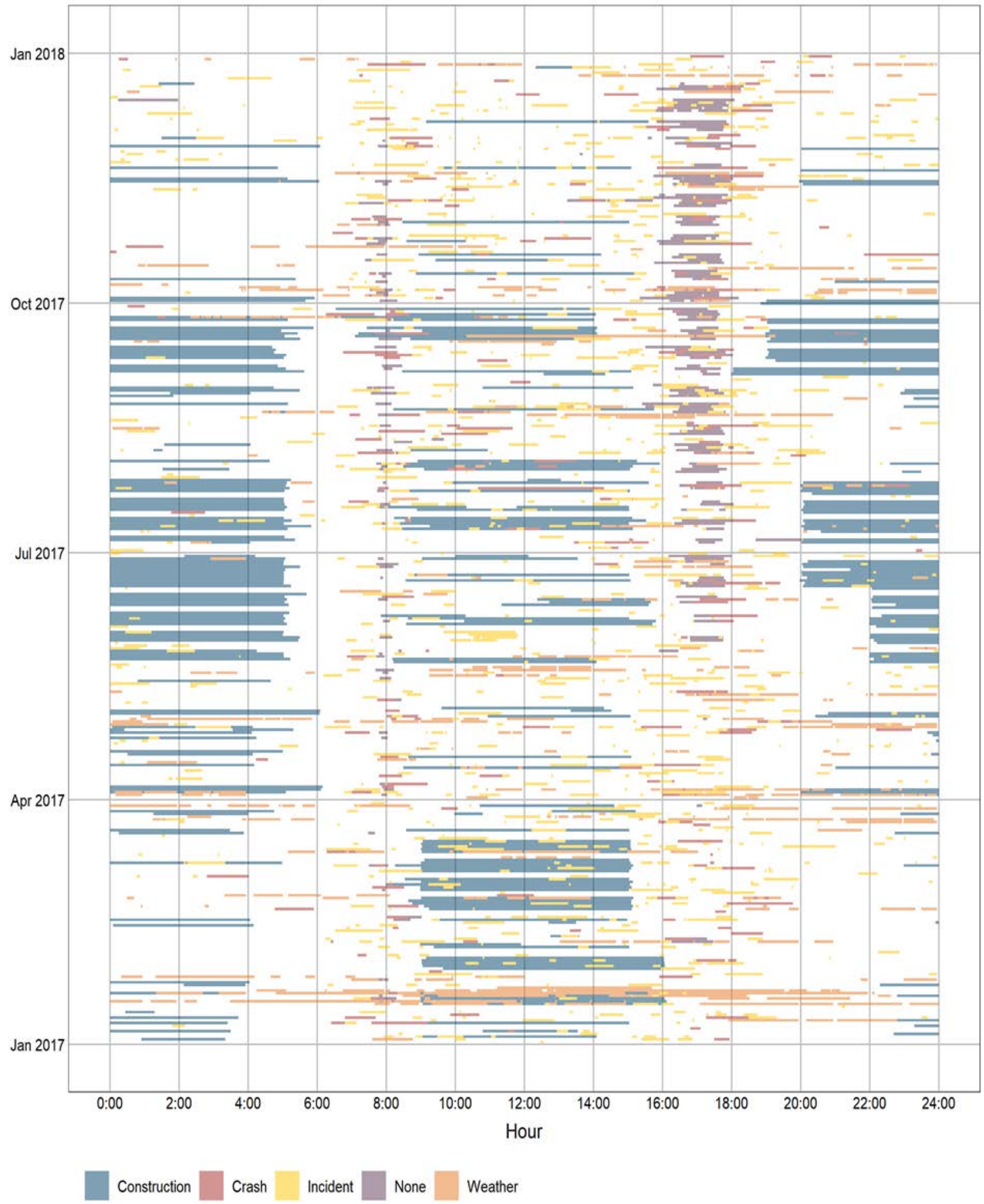


Figure 33: 2017 I-235 Westbound

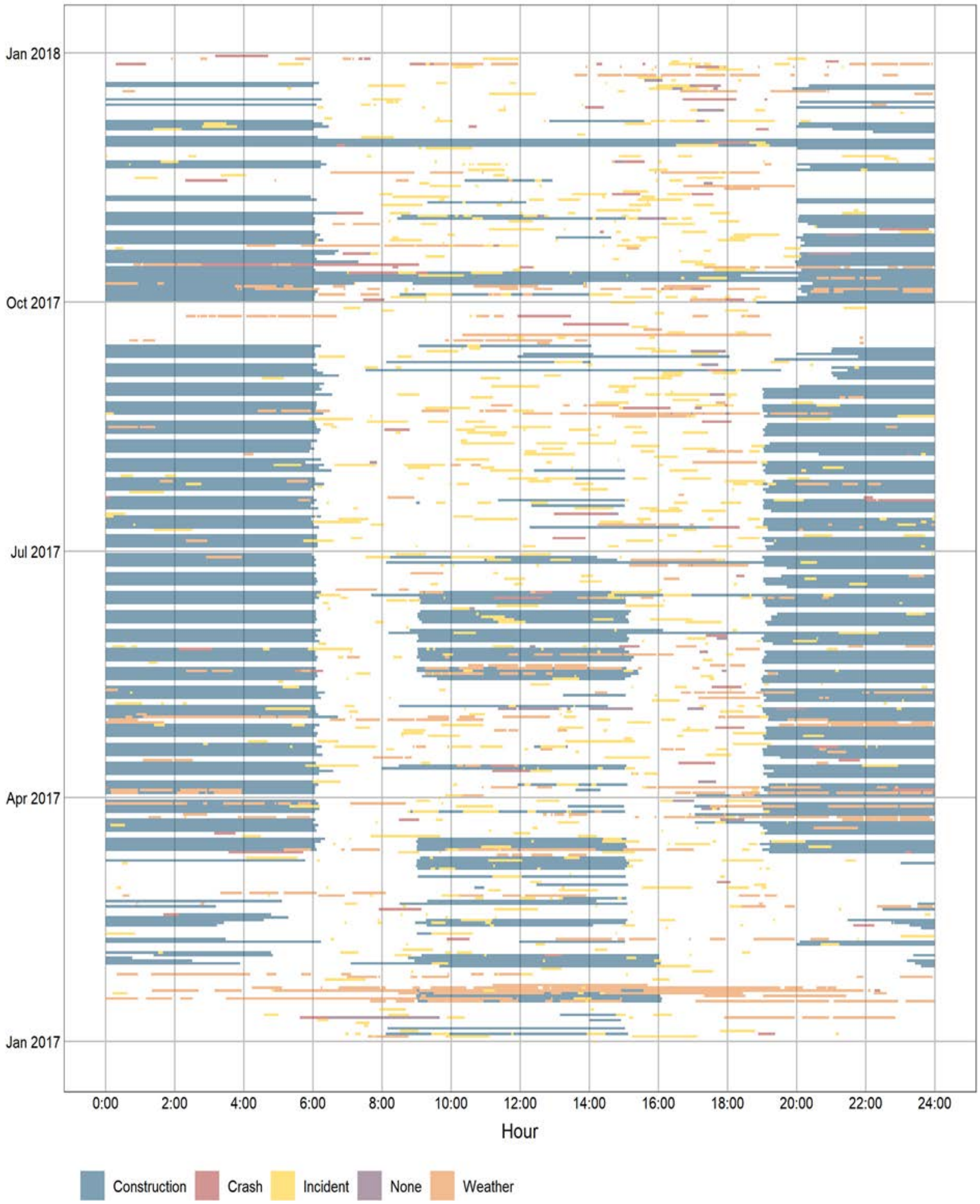


Figure 34: 2017 I-35 Northbound

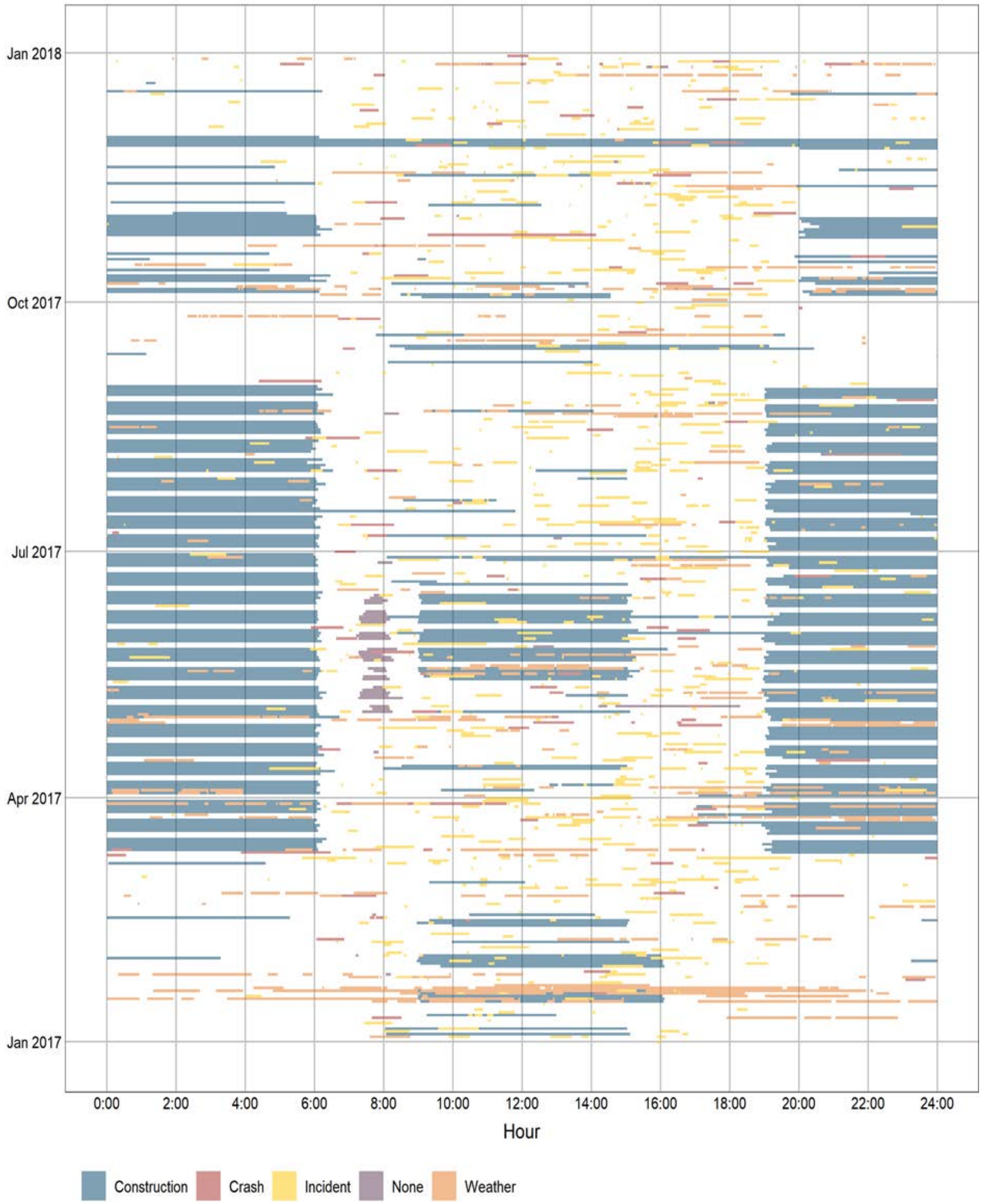


Figure 35: 2017 I-35 Southbound

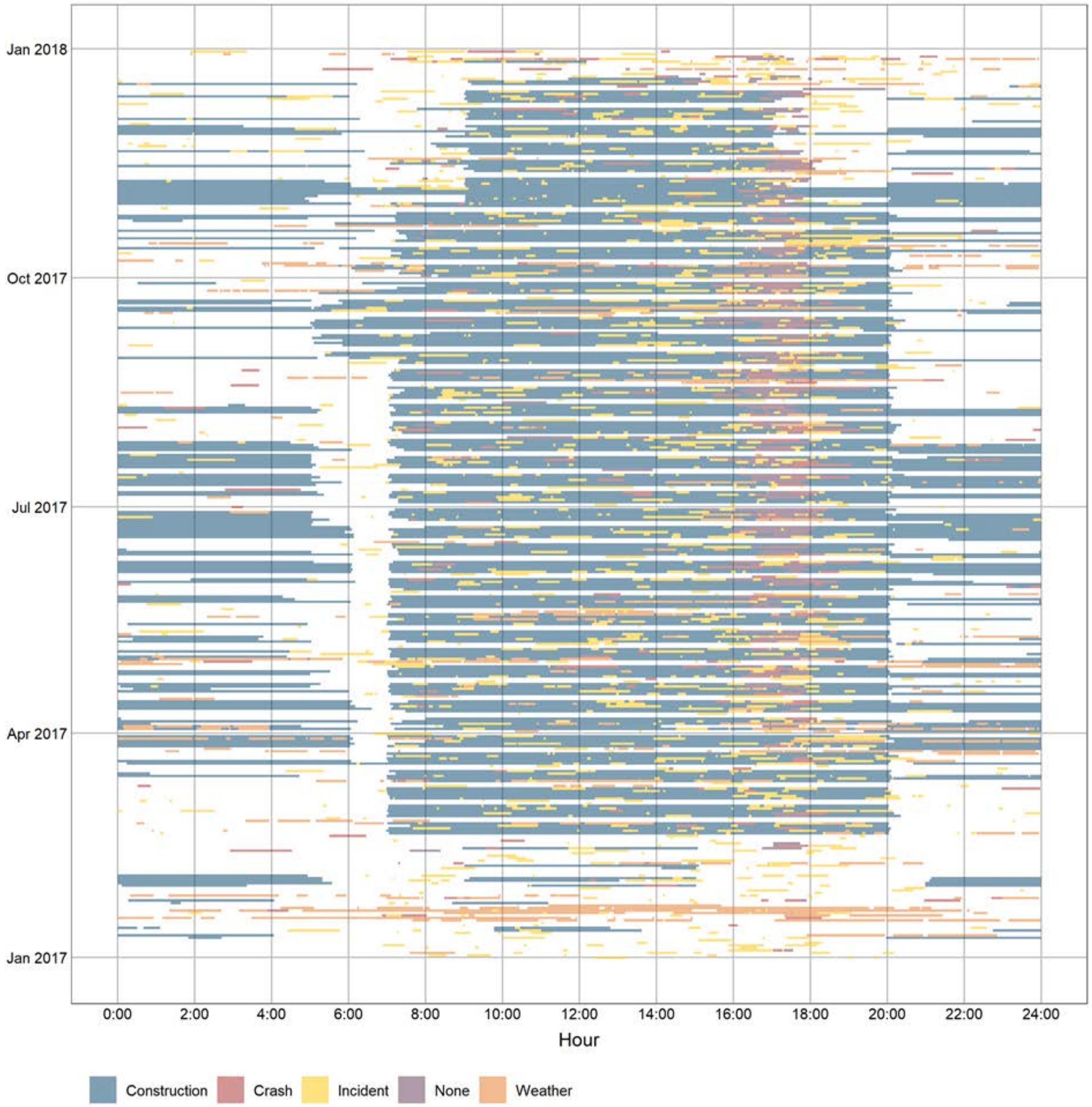


Figure 36: 2017 I-80 Eastbound

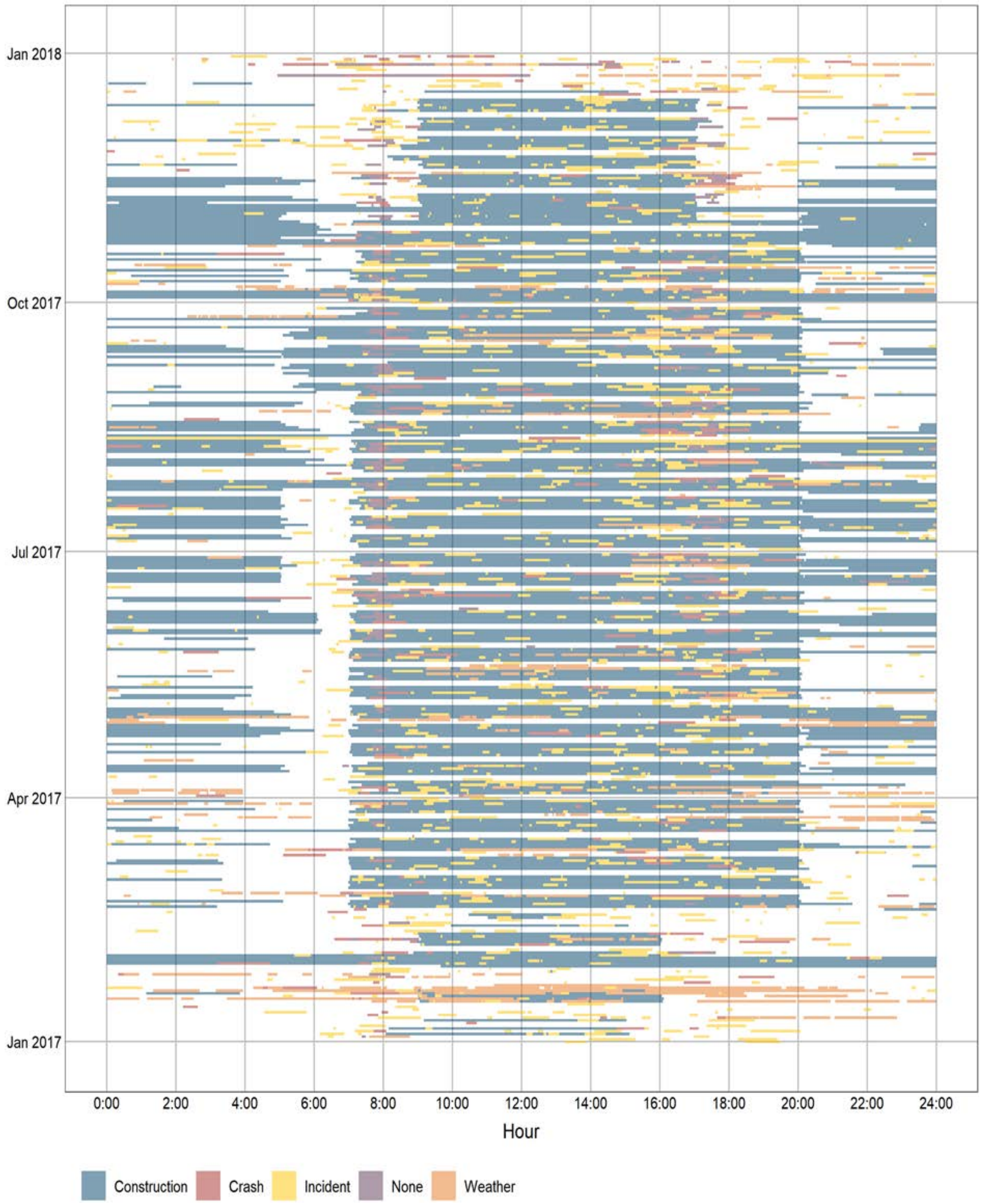


Figure 37: 2017 I-80 Westbound

Segment Level

The ATMS event data set was converted to a time series by segment and corridor and associated with the prevailing segment speed during a 15-minute window in which the event was active. As events can have widely varying traffic impacts, a simplistic assumption was applied in that any event within a corridor (I-35, I-80, I-235) was correlated with reduced speeds for all segments within that corridor in the same direction as the event. The summary congestion impacts and resulting hours of congestion are shown in Table 9.

Table 9: Congestion Causing Event Metrics and Trend

	2016	2017	
	Full Day	Full Day	Peak
Hours of Occurrence	24,284	20,253	5,923
Construction	20,033	15,150	2,994
Crash/Incident	3,996	4,224	2,092
Slow Traffic	250	874	835
Hours of Congestion	727	945	754
Construction	150	198	102
Crash/Incident	494	451	365
Slow Traffic	83	296	286

The top half of Table 9 shows how often various congestion causing events occur. The primary event is construction which is present over 20,000 hours per year, but as shown in the corridor visual scans the primary construction period is at night when traffic volumes are lower. The nighttime predominance of construction yields only 150 to 200 hours of congestion (speeds below 45 mph).

Conversely, crashes and incidents are relatively uncommon, impacting at least one segment of the studied corridors nearly 4,000 hours per year. Half of the hours with a crash or incident present occurred during the peak periods of the day. Crashes and incidents result in a greater likelihood of freeway speeds dropping below 45 mph as around 350 to 400 hours of congestion during the peaks were observed because of crashes or incidents, or about 20 percent of the duration a crash or incident was present during the peaks.

Mobility Summary

Mobility analysis identified the primary sources of congestion: bottlenecks, weather, incidents/crashes, and construction/work zones. The hours of congestion analysis identified increasing levels of slow roadway speeds regardless of source of congestion. The volume-based bottleneck analysis identified much of the freeway system on both I-35/I-80 and I-235 are exhibiting LOS D as a worst-case condition. The Highway Capacity Manual describes LOS D as restricted flow and regular delays, a description that lines up well with previously described reliability findings. The recurring delays on these corridors are exacerbated by other sources of congestion that lead to more significant breakdowns. One source known to have significant effects statewide is adverse weather. As of yet, data from the NWS has yet to be tied directly to speed data and the calculation of hours of congestion, though this remains a future opportunity.

The sources of construction and crashes/incidents were examined at the corridor and segment level to determine the impact they have on mobility. Construction identified by the TMC was typically work at night and caused little impact to roadway speeds. Conversely, crashes and incidents tended to flare up during the peaks and resulted in 350 to 400 hours of congestion each year across all segments.

CRASH ANALYSIS

Iowa DOT crash data from 2013 to 2017 was used to analyze crash trends in the study area. The crash analysis considered:

- The number and rate of fatalities and serious injuries on the study network and number of non-motorized fatalities and serious injuries in relation to federal performance measures.
- An assessment of major crash trends to understand characteristics associated with crashes (e.g., contributing factors, crash types, severities, and environmental conditions associated with crashes).
- A spatial analysis of where crashes are most frequent or most severe on the study network.

Analysis Methods

Descriptive analyses were conducted and tabulations were developed to show the overall number of fatalities and serious injury crashes as well as crash trends in the study area.

In addition, segments with potential for safety improvements were identified by calculating crash rates on the segments and comparing them to statewide averages. Traffic Message Channel Segment information was used to define segments. Traffic volume data maintained by INRIX and crashes from the Iowa DOT were linked to these segments. The crash rates were compared to Iowa DOT information about average crash rates per facility type. To consider crash severity, the crash rates per segment were also converted to a crash cost per vehicle miles travelled per segment by applying crash severity cost information from the Iowa DOT[3]. Finally, a GIS crash cluster analysis (Getis-Ord GI* statistic (known as GI*)) was conducted to identify localized clusters or pockets of crashes with densities well above or below typical values for the studied system. Crash conditions were evaluated using the common segment geography for mapping using GIS tools.

Crash Trends

MAP-21, adopted in 2012, required state DOTs to annually establish safety performance targets for the five federal safety performance measures shown in Table 10. The numbers shown in Table 10 are statewide rolling 5-year averages. The current target number of fatalities is less than or equal to 353.6 fatalities per year statewide. The table shows the average number of fatalities and injuries for the study area in the most recent 5-year period. As shown, the Des Moines area accounts for approximately 6 percent of the statewide fatalities and serious injuries.

[3] *Iowa DOT, Office of Traffic and Safety, Traffic Safety Improvement Program* https://iowadot.gov/traffic/traffic-and-safety-programs/tsip/tsip-program

Table 10: Summary of Study Area Federal Safety Performance Functions

MAP-21 Performance Measure	Current Statewide Target (2015–2019)[2]	Study Network Crash History (2013–2017)
Number of Fatalities/Year	353.6	10.4
Rate of Fatalities (Fatalities Per 100 Million Vehicle Miles Travelled)	1.047	Not Available
Number of Serious Injuries	1,483.7	102
Rate of Serious Injury (Serious Injuries Per 100 Million Vehicle Miles Travelled)	4.391	Not Available
Combined Number of Non-Motorized Fatalities and Serious Injuries	149.8	Not Available

Standard crash tabulations were developed to understand crash trends and major contributing factors. These assessments were conducted for the freeways and off-system "major roads" included in the project study. The analysis considered:

- Number of crashes by severity per year
- Number of people injured per year
- Crash distribution by age and gender
- Crash frequency by time of day, day of the week, and month of the year
- Impairment involved
- Contributing circumstances
- Major crash cause
- Most frequent crash types
- Crash time of day, day of week, and month of year.

In summary, there were 5,556 crashes on the freeways and 19,124 crashes on major roads during the study period (Figure 38). When looking at the year to year change in the number and severity of crashes it is important to consider that the number and type of crashes will vary year-to-year due to the natural random variation in rare events, such as crashes. Nonetheless, changes in traffic volume, weather events, work zones, and other factors also influence the number and severity of crashes. For comparison purposes Iowa DOT 2013–2015 city vehicle miles travelled (VMT) data was used to estimate the year to year change in traffic volumes on the freeways and major roads in Des Moines. Between 2013 and 2015 there was an 11 percent growth in VMT on the municipal interstate system but an 8 percent growth in crashes; growth in traffic volume outpaced the increase in crashes. In contrast, during the same period traffic volume on the municipal primary system in the city grew by 1 percent yet the number of crashes on the major roads in the project study grew by 20 percent. This increase was larger than expected. While increases may be due to the natural variation in crashes or increases in crash frequency, other possible explanations for the increase should also be explored. Other reasons for such a change in crash frequency may be: changes in crash reporting, changes in data systems, or potentially changes in data policy.

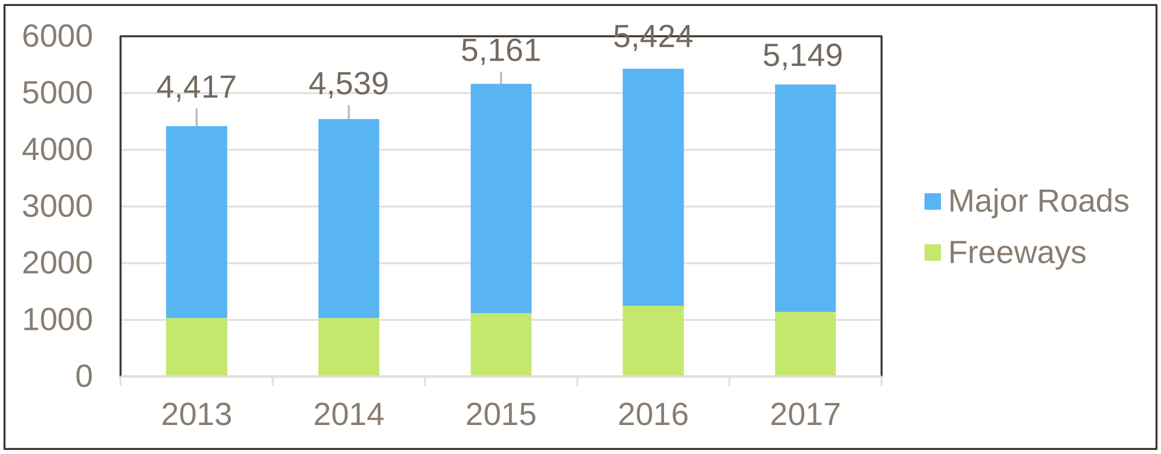
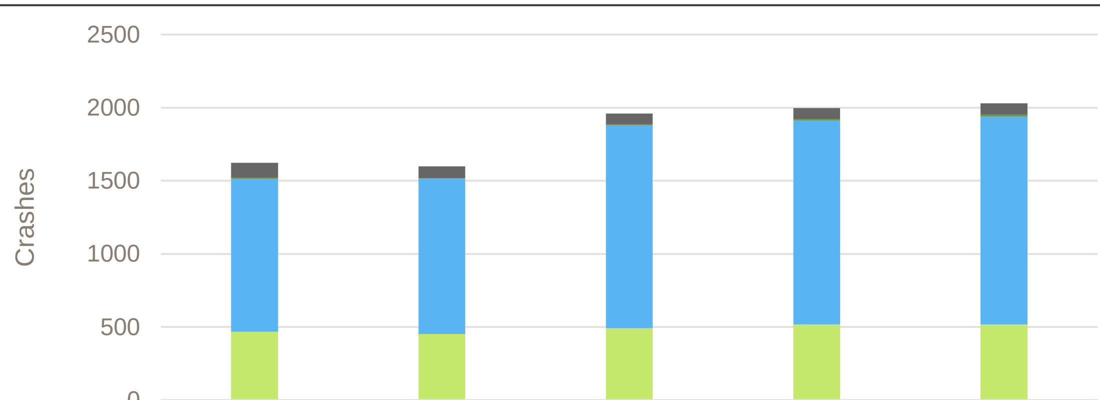


Figure 38: Crashes Per Year (All Severities)

On both the freeways and the major roads approximately 99 percent of the crashes were minor injury or property damage only. In total, the 24,680 crashes in the study period resulted in 460 people being killed or suffering major injuries (Table 11). Impairment was a factor in 44 crashes on the freeways, and 61 crashes on the major roads. Figure 39 summarizes other characteristics of crashes on the study network.



	2013	2014	2015	2016	2017
majinjury	100	81	75	74	78
fatalities	11	6	8	12	15
possinjury	1044	1061	1385	1393	1419
mininjury	468	452	493	518	519

Figure 39: Distribution of Injuries Caused by Crashes

Table 11: Summary of Crash Trends

Consideration	Freeway	Major Roads
Crashes	5,556	19,124
Fatalities and Major Injuries (People)	102	358
Most frequent crash type	All Severities: Rear End, Single Vehicle, Sideswipe Fatal or Major Injury: Single vehicle	All Severities: Rear End, Broadside, Same Direction Sideswipe, Angle (left-turn) Fatal or Major Injury: Single vehicle, Broadside, Rear-end
Most Frequent Crash Cause	Followed Too Close, Driving too fast for conditions	Followed too close, and Failure to Yield ROW
Most Frequent Crash Day and Time of Day	Tuesday, 5:00 to 6:00	Friday, 4:00 to 6:00
Most Frequent Crash Month	December	October, but relatively evenly distributed across the year
Age and Gender	20–30; slightly more men (801 crashes involving drivers under 20)	20–30, slightly more men (3,673 crashes involving drivers under 20)

Crash contributing circumstances are summarized in Table 12. “None apparent” was the most common contributing circumstance. Several contributing circumstances, which could potentially be addressed with ICM strategies, were common in the system:

- **Wet or icy surface conditions** - The second most common reported contributing circumstance on both the freeways and major roads. Approximately 20 percent of the crashes (1,119) on the freeways had surface condition (wet or icy) as a contributing circumstance, in contrast only 7 percent of the crashes (1,299) on major roads had surface condition as a contributing circumstance.
- **Work zones, congestion, and incident-related congestion** - Contributed to approximately 6 percent of the freeway crashes (357). On the major roads, only 1 percent of the crashes (205) were attributed to these types of factors.

Table 13 summarizes major crash causes attributed to the crashes on both the freeways and local roads. The graphic shows the relationship between crash causes on freeways and arterials. On both the freeways and major roads, the most common crash cause was “followed too close.” The second most common crash cause on freeways was “driving too fast for conditions,” and on the major roads it was “failure to yield right of way.” Again, both of these causes could potentially be addressed through ICM strategies.

Table 12: Crash Contributing Circumstance

Contributing Circumstance	Freeway	Major Roads	Total
None apparent	3811	17135	20946
Surface condition (e.g., wet, icy)	1119	1299	2418
Work Zone (roadway-related)	179	162	341
Not reported	117	147	264
Unknown	22	177	199
Traffic backup, regular congestion	111	33	144
Other	39	51	90
Traffic backup, prior crash	67	10	77
Debris	67	10	77
Slippery, loose, or worn surface	7	38	45
Obstruction in roadway	13	11	24
Non-highway work	2	16	18
Traffic control obscured	1	15	16
Disabled vehicle		11	11
Traffic backup, prior non-recurring incident	9	2	11
Shoulders (none, low, soft, high)	1	4	5
Ruts/holes/bumps	1	3	4

Table 13: Crash Causes

Crash Cause	Freeway	Major Roads	Total
Followed too Close	1320	3879	5199
Driving Too Fast for Conditions	881	836	1717
Lost Control	495	788	1283
Swerving/Evasive Action	403	263	666
Ran Off Road-Right	310	285	595
Improper/Erratic Lane Changing	278	523	801
Ran Off Road – Left	249	83	332
Driver Distraction	159	835	994
FTYROW	134	3429	3563
Operating Vehicle in Reckless, Negligent Manner	93	594	687
Ran Traffic Signal	47	1921	1968
Made Improper Turn	8	760	768

The distribution of crashes by time of day is shown in Figure 40 and Figure 41 on the major roads and freeway, respectively. As shown in Figure 41, the distribution of crashes by time of day on the freeways is consistent with peak travel periods. On the major roads (Figure 40), the distribution of crashes by time of day also shows the mid-day peak period typical of urban areas.

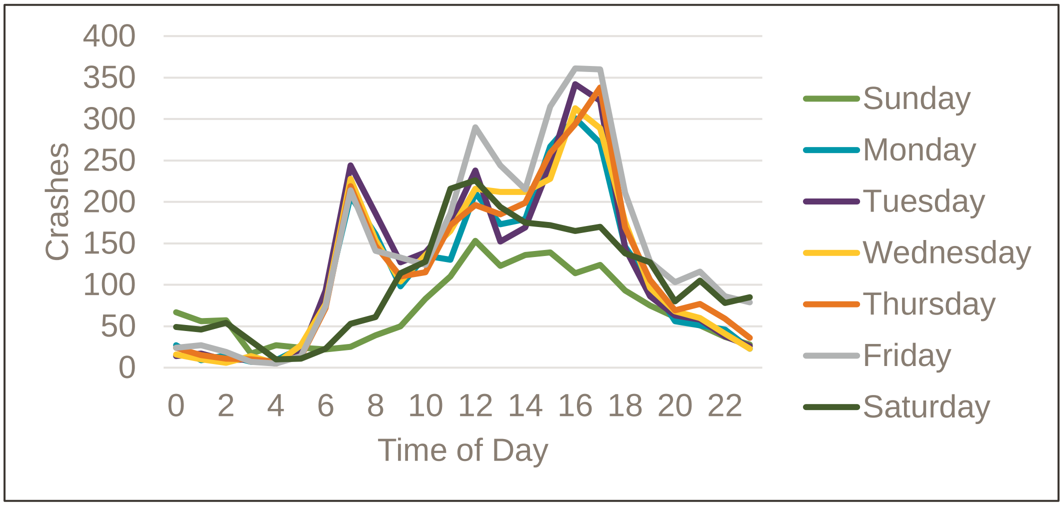


Figure 40: Distribution of Major Road Crashes by Time of Day

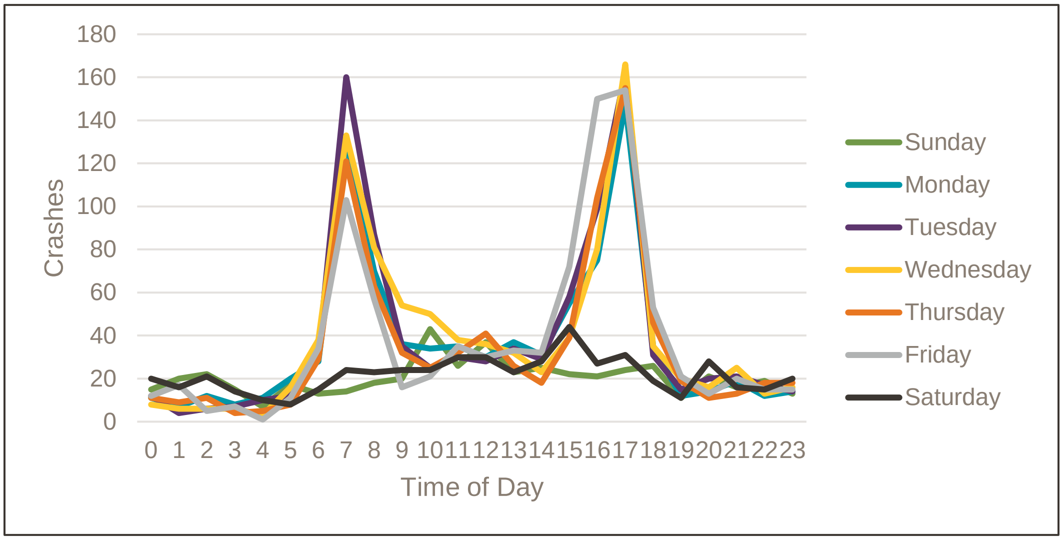


Figure 41: Distribution of Freeway Crashes by Time of Day

Spatial Crash Analysis

The traffic volume, roadway segment, crash location, and crash severity information was combined into three maps showing the spatial characteristics of crashes:

- **Crash rate** (Figure 42) - Crashes per 100 million vehicle miles traveled (MVMT) on the freeway and major road compared to average crash rates for comparable facilities published by Iowa DOT. The segments were categorized as:
  - **Good** – The segment crash rate is less than 85 percent of the statewide average
  - **Fair** – The segment crash rate is between 85 percent and 115 percent of the statewide average
  - **Poor** – The segment crash rate is greater than 115 percent of the statewide average

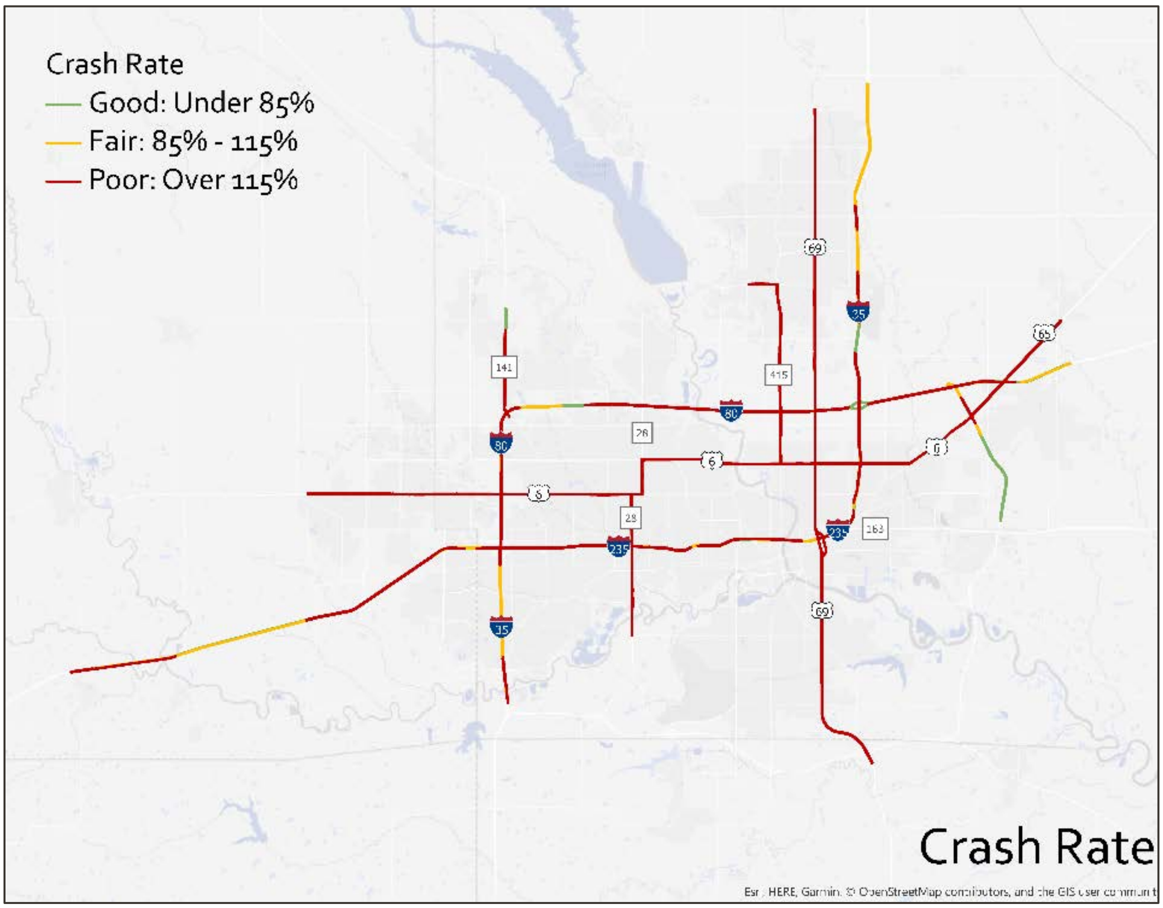


Figure 42: Crash Rate Comparison to Statewide Average Rates by Facility Type

- **Crash Cost Index** (Figure 43) – The crash costs per segment were calculated as a function of crash severity using Iowa DOT crash cost information. The costs per segment were normalized using VMT. The resulting costs per VMT per segment were compared to an average value estimated from Iowa DOT average crash rates by severity and the DOT crash severity costs. The segments were categorized as:
  - **Good** – The segment crash rate is less than 85 percent of the statewide average
  - **Fair** – The segment crash rate is between 85 percent and 115 percent of the statewide average
  - **Poor** – The segment crash rate is greater than 115 percent of the statewide average

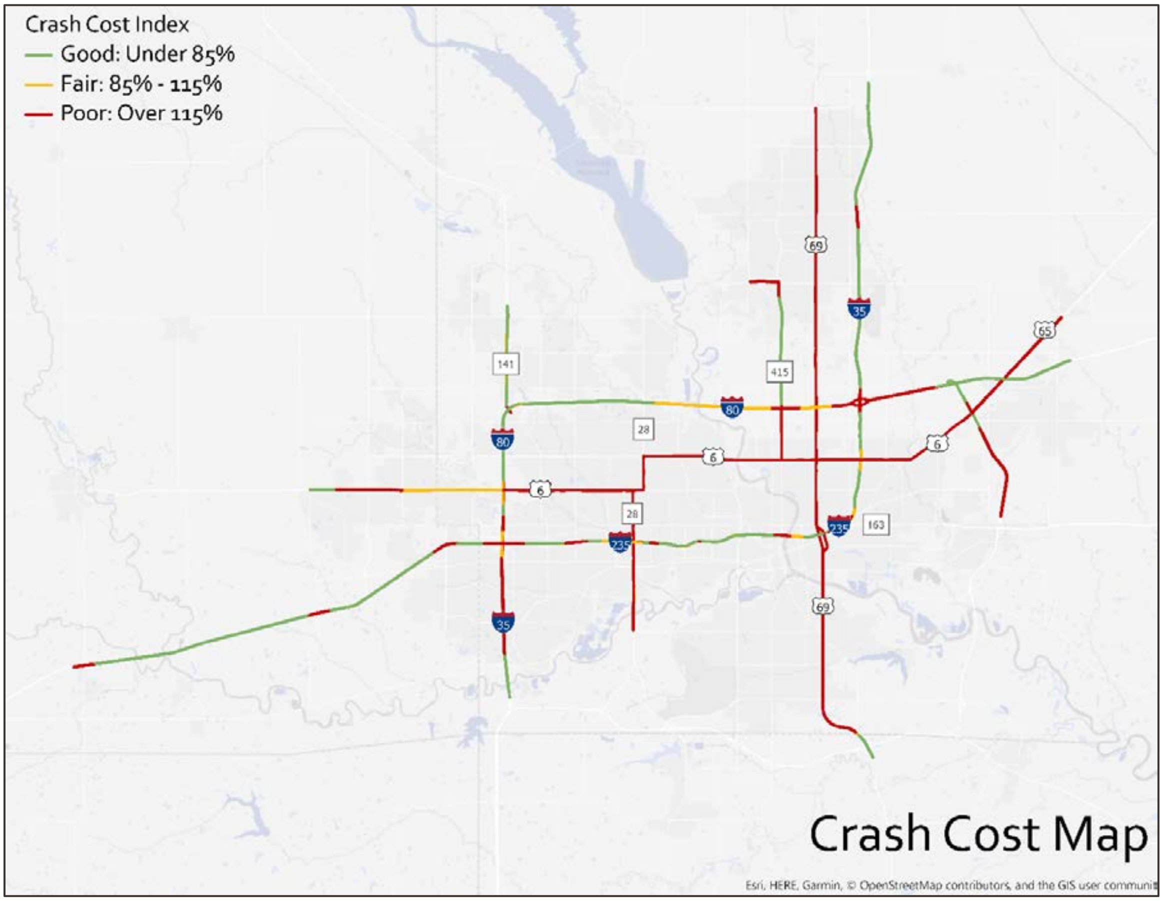


Figure 43: Crash Cost Comparison to Statewide Average Costs by Facility Type

- **Crash Hot Spot** (Figure 44) – The crash hot spots were calculated using GI* to identify localized clusters or pockets of crashes with densities well above or below typical values for the studied system. Each segment was categorized as cold or hot spots or not significant with a degree of confidence ranging from 90 to 99 percent.

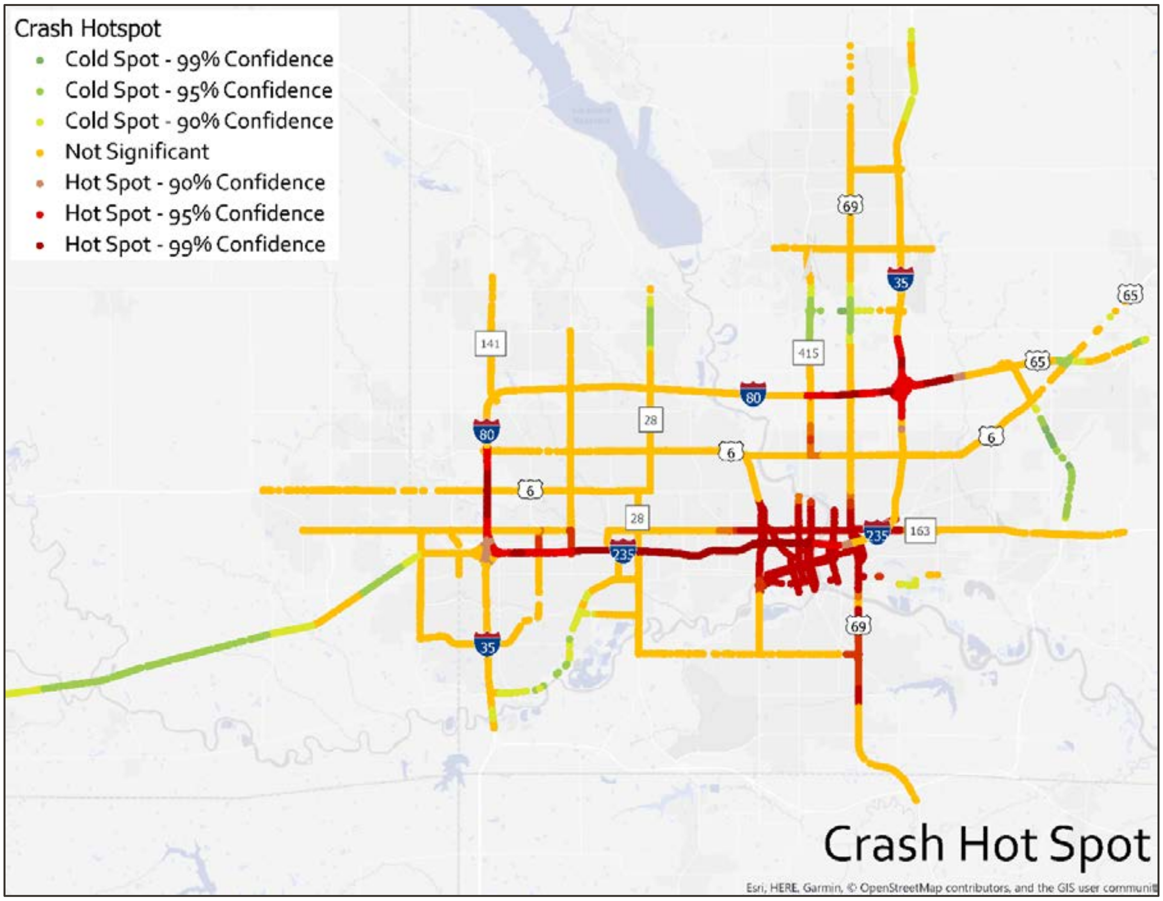


Figure 44: Crash Hot Spot Map – Freeway and Major Roads

Comparing these maps helps to identify trends and notable locations for further consideration in the project analyses:

- The crash rate analysis (Figure 42) shows that most Des Moines area freeways and major roads have crash rates higher than average.
- Comparing the crash rate (Figure 42) and crash cost (Figure 43) shows differences in frequency and severity of crashes by facility type. On the freeways, the crash rate is above average; however, the crash cost index in many locations is lower than average. The crash cost index is high on the freeways near the interchanges of I-235 and I-35/I-80 (southwest and northeast junctions) and I-235 and IA 163. However, the crash cost index stays relatively high on the major roads.
- The hot spot maps (Figure 44) show the locations with statistically significant higher crash density than expected. Hot spots include I-235 between the southwest junction and approximately Pennsylvania Avenue; on I-35/I-80 from the southwest junction north to approximately the Hickman Interchange; and near the northeast junction. The crash cost index shows that the severity of crashes in many of these locations is relatively low. However, there are exceptions particularly near the northeast junction of I-235 and I-35/I-80. These segments reflect high crash cost and statistically significant hot spots may become priorities for solutions.

Considering the major roads, the crash rates and crash cost index are above average; however, there are very few locations showing as statistically significant hot spots. This demonstrates the relatively consistent distribution of crashes across the system.

Congested Conditions Related Crash Performance Trends

Crashes have been analyzed for their characteristics and reduced to metrics like a crash rate (frequency per unit exposure) or crash density (frequency per unit distance) to spotlight locations of current safety concern. Yet, when considering ICM strategies, the review of crashes can benefit from considering conditions present when a crash event occurred. Data analysis from the sources gathered allows the ability to consider both the impact of crashes on congestion, and the impact of high speed, high volume operations mixed with potential impacts from weather and work zones on the likelihood of a crash occurring. Evaluation of the impact of crashes on congestion has yielded preliminary findings, discussed in the Incident Analysis section. Future work to connect the data analysis to crash prediction models will investigate the ability of the integrated project data to support crash causation by source of congestion.

Crash Analysis Summary

There were 24,680 crashes on freeways and major roads in the study area between 2013 and 2017. In this same period 460 people were killed or suffered major injuries. Most of the crashes in the study area are possible injury or property damage only. Crash trends do show an increase in the number of crashes during this period. In addition, there is a significant increase in the number of crashes on the major roads between 2014 and 2015 and sustained through 2017 that deserve more research.

As expected there are differences in the characteristics of freeway and major road crashes. Table 11 summarizes major crash trends on these facilities. Trends that may respond to ICM strategies include the frequency of crashes with contributing factors related to surface condition, work zones, congestion, and incident related congestion. On both freeways and major roads, crashes were most frequently attributed to following too closely, driving too fast for conditions, and failure to yield right of way. Managing traffic flow may reduce the risk of these crashes.
The average crash rate for much of the system is relatively high compared to the statewide average. Therefore, comparing crash costs and hot spots provides a means of assessing where crashes may be over-represented and the severity of crashes on the system. On the freeway system, the northeast and southwest junction appear as priority locations.

CONCLUSIONS – EXISTING CONDITIONS

The study area exhibits safety, mobility, and reliability challenges that are based on a proposed set of performance measures. Crash rates on key roadways in Des Moines routinely exceed statewide averages, though many segments with high crash frequencies are predominantly experiencing property-damage-only crashes. Reliability analysis shows that the east-west portion of I-235 and the north-south portion of I-35/I-80 experience the highest percentage of segments with speeds at 45 mph or below, but most other freeway segments fall within the moderate range for multiple travel time-based performance measures. With a trend of decreasing reliability at the system level over the 5-year period, the full length of I-35/I-80 and I-235 could benefit from reliability-enhancing strategies. Further, the mobility analysis looked at traffic volumes as an indicator of slow speeds and likely breakdowns and found that much of the core freeway loop is operating at LOS D for worst-case peak conditions with a potential bias toward missing LOS E/F segments when estimating mobility based on sensor counts and not demanding volume. With heavy volumes creating pressure on the system, the analysis of source congestion shows that crashes and incidents add to recurring peak congestion because they are concentrated during the peaks. There is a spike in hours of congestion when crashes or incidents are present.

Further coordination with the study advisory team and key stakeholders defined a vision, goals, and objectives for the Des Moines ICM. The findings of the existing conditions analysis provided the data-driven assessment of how the system compares to absolutes (statewide crash rates), and how key segments on the system compare relative to other segments within the system. Combining this data with needs expressed from operating partners and other key stakeholders will define locations where early investment in ICM strategies should be targeted.

Appendix B: ICM Strategy Descriptions

This appendix provides individual ICM strategy tables containing more specific information pertaining to each strategy. Readers can reference individual strategy tables to gain more context in how they work toward the ICM vision, goals, and objectives outlined in the previous chapter. Specifically, each table contains the following types of information:

- Description – Brief description of the ICM strategy that provides context of how the strategy might satisfy ICM related goals and objectives.
- ICM Category – Identifies the high-level ICM category, from Figure 5 that the ICM strategy belongs (e.g., foundational strategy, fundamental strategy, active and advanced strategy, system modification, and emerging strategy)
- Anticipated Benefits – Provides a listing of high-level benefits that the ICM strategy may provide.
- Provided Functionality – Provides a concise statement of the overarching objective of the strategy.
- Prerequisite Functionally Required – Select strategies may require other strategies or ICM elements to be present or implemented prior to the implementation of the strategy presented. This field provides the required functionality that must be in place before the strategy can be implemented successfully.
- Complementary and/or Supported Strategies – This field identifies the strategies that subject strategy may support and/or may be a prerequisite strategy for successful implementation.
- Examples – This provides the location, entity, or program that has implemented the subject strategy.

Table 14: ICM Strategies Grouped by Transportation Functional Area

Event Management	Infrastructure Enhancement / Management
Traffic Incident Management	Park and Ride Lots
Planned Special Event Management	Acceleration / Deceleration Lanes
Work Zone Management	Access Control
Weather Responsive Traffic Management	Bottleneck Removal
Freight Operations and Management	Freight-Rail Improvements
Freeway Traffic Management	Cycle Tracks
Traffic Data Collection and Processing	Crash Investigation Sites
Network Monitoring / Surveillance	Connected and Automated Vehicles
Traveler Information Dissemination	Smart Cities
TMC Enhancement / Expanded Operations	**Travel Demand Management**
Ramp Terminal Treatments	Carpooling / Vanpooling
Ramp Closure	Telecommuting
Special Use Ramps	Transportation Management Associations
Ramp Metering	Dynamic Routing
Adaptive Ramp Metering	Dynamic Ridesharing
Dynamic Junction Control	Flexible Work Hours
Dynamic Shoulder Lanes / Part-time Shoulder Use	Bike Sharing
Dynamic Truck Restrictions	Congestion Pricing
Arterial Traffic Management	Mobility-as-a-Service
Traffic Signal Management	**Public Transportation Management**
Dynamic Parking Wayfinding	Transit Incentives
Dynamic Parking Reservation	Transit Lanes
Dynamically Priced Parking	Dynamic Transit Capacity Assignment
Adaptive Traffic Signal Control	Fare Strategies
Traveler Information	Bus Rapid Transit
Comparative Travel Time Messaging	Transfer Connection Protection
Predictive Traveler Information	Transit Signal Priority
Dynamic Speed Advisories / Limits	Express Bus Service
Queue Warning	Mobility on Demand

7.5.5 Event Management ICM Strategies

ICM Functional Area / Tactic	ICM Category	ICM High-Level Benefits								
		Safety / Response	Mobility / Accessibility	Demand Reduction / Shift	Travel choice / Decision Making	Return on / Use of Existing Investment	Efficiency / Productivity	Institutional Cooperation	Environmental Impact	Customer Experience / DOT Perception
Event Management										
Traffic Incident Management	Fundamental	•	•	•	•	•	•	•	•	•
Planned Special Event Management	Fundamental	•	•	•	•	•	•	•	•	•
Work Zone Management	Fundamental	•	•	•	•	•	•	•	•	•
Weather Responsive Traffic Management	Fundamental	•	•	•	•	•	•	•	•	•
Freight Operations and Management	Fundamental	•	•	•	•	•	•	•	•	•

Traffic Incident Management

	Traffic Incident Management (TIM)
Description	Planned and coordinated multi-disciplinary process to detect, respond to, and clear traffic incidents so that traffic flow may be restored as safely and quickly as possible. This coordinated process involves several public and private sector partners, including law enforcement, fire and rescue, emergency medical services, transportation, public safety communications, emergency management, towing and recovery, hazardous materials contractors, and traffic information media. Benefits of traffic incident management include congestion reduction, economic savings, fuel savings, increased incident clearance times, secondary crash reduction, increased responder safety, and reduced morbidity rates. This strategy builds upon strategies already employed by the Iowa DOT and their partner agencies, where appropriate, such as: • Corridor/regional specific TIM plans • Reoccurring, multi-agency TIM training • Regularly scheduled TIM coordination meetings • After-action reviews • Highway Helper Freeway Service Patrol Additional strategies that could potentially be investigated depending on needs include: • Towing and recovery call lists – These lists are prepared, distributed, and readily available to use when traffic incidents occur. They help to improve emergency response times, reducing overall incident duration, and impact on traffic flow. • Towing incentives – Towing incentives are effectively bonuses that towing and wreckers can obtain by quickly removing incidents from travel lanes. The incentive amount varies based on how quickly the agency responds to and/or removes vehicles from the roadway. These incentives help improve incident clearance times. • Pre-staged ITS and TIM equipment – This strategy consists of deploying equipment at locations near trouble spots or where incidents may occur (e.g., work zones) so that emergency responders can use or deploy them more quickly than if they were stored at a centralized location. • Mile reference markers – This strategy consists of deploying mile post markers at frequent intervals (one-tenth or two-tenths of a mile) along the freeway so that drivers and/or motorists can quickly and accurately report the location of incidents. This reduces response time so emergency responders can travel directly to the location rather than traveling more slowing or requesting assistance to find it.

ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• TMC incident detection • TMC incident dispatch coordination • Emergency response management
Prerequisite Functionality Required	• Network surveillance • Traffic information dissemination
Complementary and/or Supported Strategies	• Connected and automated vehicles • Smart cities • Work zone management • Predictive traveler information
Examples	• Iowa Traffic Incident Management Service Layer Plan • Kansas Traffic Incident Management Program • Wisconsin Traffic Incident Management Enhancement Program • Metro Atlanta TIME Task Force

Planned Special Event Management

	Planned Special Event Management
Description	Planned special events (PSEs) include sporting events, concerts, festivals, and conventions occurring at permanent multi-use venues. They also include less frequent public events such as parades, firework displays, bicycle races, sporting games, motorcycle rallies, seasonal festivals, and milestone celebrations at temporary venues. Managing travel for planned special events involves advanced operations planning, stakeholder coordination and partnerships, developing a multi-agency transportation management plan, raising awareness of public and event patrons of potential travel impacts, and coordinating agency services and resource sharing. Operational phases of planned special event management include Program Planning, Event Operations Planning, Implementation Activities, Day of Event Activities, and Post-Event Activities.
ICM Category	Fundamental strategy
Anticipated Benefits	Improved safety and emergency response Improved accessibility and mobility Reduced or shifted demand Enhanced traveler choice and decision making Increased return on and use of existing investment Improved transportation efficiency and productivity Improved institutional cooperation Reduced environmental impact Improved customer experience and perception
Provided Functionality	Event coordination and management
Prerequisite Functionality Required	Network surveillance Traffic Information Dissemination (pre-trip and en-route)
Complementary and/or Supported Strategies	Ramp closure Ramp metering Adaptive ramp metering Network surveillance Traffic information dissemination Traffic incident management Traffic signal improvements Park and ride lots Carpooling/vanpooling Transportation management associations Transit lanes Transit incentives Connected and automated vehicles
Examples	G-20 Summit (Pittsburgh, PA) 2008 Democratic National Convention (Denver, CO)

Work Zone Management

	Work Zone Management
Description	This strategy involves minimizing traffic delays, maintaining motorist and worker safety, completing roadwork in a timely manner, and maintaining access for businesses and residents. Different methods of work zone management include: coordinating road projects, incident management, lane closure politics, traffic control, use of ITS, and work zone speed management.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Work zone management • Work zone traffic control
Prerequisite Functionality Required	Depending on the specific application, could include: • Network Surveillance (portable and fixed location) • Traffic information dissemination (Portable and fixed location) • Variable speed limits • Dynamic routing • Dynamic truck restrictions • Queue warning • Flexible work hours • Carpooling/vanpooling
Complementary and/or Supported Strategies	• Traffic incident management • Active traffic management • Ramp closure • Ramp metering
Examples	Widely implemented, including: • I-75 Ambassador Bridge Gateway Project (Michigan DOT) • I-85 widening (North Carolina DOT) • I-279 Fort Pitt Bridge and Tunnel (Pennsylvania DOT) • I-94/894 (Zoo Interchange) Reconstruction (Wisconsin DOT)

Weather Responsive Traffic Management

	Weather Responsive Traffic Management
Description	Includes strategies that utilize road weather data (using field devices and vehicles) for traveler information, traffic control, and winter maintenance activities. There are three types of road weather management strategies that may be employed in response to environmental threats: advisory, control, and treatment strategies. Advisory strategies provide information on prevailing and predicted conditions to both transportation managers and motorists. Control strategies alter the state of roadway devices to permit or restrict traffic flow and regulate roadway capacity. Treatment strategies supply resources to roadways to minimize or eliminate weather impacts. Many treatment strategies involve coordination of traffic, maintenance, and emergency management agencies. These mitigation strategies are employed in response to various weather threats including fog, high winds, snow, rain, ice, flooding, tornadoes, hurricanes, and avalanches.
ICM Category	Fundamental strategy
Anticipated Benefits	Improved safety and emergency response Improved accessibility and mobility Reduced or shifted demand Enhanced traveler choice and decision making Increased return on and use of existing investment Improved transportation efficiency and productivity Improved institutional cooperation Reduced environmental impact Improved customer experience and perception
Provided Functionality	Winter weather maintenance management Maintenance decision support Roadway environmental monitoring
Prerequisite Functionality Required	Network surveillance Traffic information dissemination Roadway environmental monitoring
Complementary and/or Supported Strategies	Predictive traveler information Dynamic routing Flexible work hours Telecommuting Dynamic speed advisories Queue warning Connected and automated vehicles Incident management
Examples	Road Condition Reporting Application (Wyoming DOT) Integrating Mobile Applications (Michigan, Nevada, Minnesota DOTs)

Freight Operations and Management

	Freight Operations and Management
Description	The use of technologies deployed to improve freight system efficiency and productivity, increase global connectivity, and enhance freight system security against common threats and terrorism. Freight operational strategies include gateway facilitation, driver identification and validation, compliance facilitation, weigh-in-motion, freight status information, and network status information. Successful implementation of one or more of these strategies could result in increased efficiency and productivity, improved reliability of service, and improved shipment and service integrity.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Freight mobility • Commercial vehicle administration
Prerequisite Functionality Required	• Network surveillance • Traffic information dissemination • Commercial vehicle administrative and management systems
Complementary and/or Supported Strategies	• Dynamic routing • Dynamic truck restrictions • Queue warning • Connected and automated vehicles • Access control • Freight rail improvements • Intersection improvements • Traffic incident management • Work zone management • Weather responsive traffic management • Adaptive traffic signal systems
Examples	• Seattle, WA (At grade rail crossings near industrial area)

7.5.6 Freeway Traffic Management

ICM Functional Area / Tactic	ICM Category	ICM High-Level Benefits								
		Safety / Response	Mobility / Accessibility	Demand Reduction / Shift	Travel choice / Decision Making	Return on / Use of Existing Investment	Efficiency / Productivity	Institutional Cooperation	Environmental Impact	Customer Experience / DOT Perception
Freeway Management										
Traffic Data Collection and Processing	Foundational		•	•	•			•		
Traveler Information Dissemination	Foundational	•	•	•	•			•		•
Network Monitoring / Surveillance	Foundational	•	•	•	•			•		•
TMC Enhancement / Expanded Operations	Foundational	•	•	•	•	•	•	•	•	•
Ramp Terminal Treatments	Fundamental	•	•			•		•		
Ramp Closure	Fundamental	•	•	•				•		
Special Use Ramps	Fundamental		•	•	•	•		•		•
Ramp Metering	Fundamental	•	•	•		•	•	•	•	
Adaptive Ramp Metering	Active and Advanced	•	•	•		•	•	•	•	
Dynamic Junction Control	Active and Advanced	•	•			•			•	
Dynamic Shoulder Lanes / Part-time Shoulder Use	Active and Advanced		•			•			•	•
Dynamic Truck Restrictions	Active and Advanced	•	•	•					•	

Traffic Data Collection and Processing

	Traffic Data Collection and Processing
Description	This component stores information that is created through operations performed by a Traffic Management Center. Data collected by the center can be used directly by operations personnel or it can be made available to other data users and archives. Center-based data collection and processing supports other fundamental, advanced and emerging strategies by providing the raw data needed to initiate appropriate response and assess performance. The Institute for Transportation has been active in this area in several capacities, including: • Establishing the Iowa DOT's open traffic data service which allows vendors and agencies to provide near real-time, proactive alerts to commercial drivers regarding traffic conditions along their routes. • Deep learning applied to wrong way driving. More specifically taking image data from TMC elements as closed circuit television cameras to detect high-risk locations and eventually automating wrong-way detection systems.
ICM Category	• Foundational strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making (e.g., enhances transportation planning and real-time decision making) • Improved institutional cooperation
Provided Functionality	• Enhances decision making
Prerequisite Functionality Required	• Communications
Complementary and/or Supported Strategies	• Supports or enhances most ICM strategies outside of system modifications.
Examples	• Widely adopted

Network Monitoring/Surveillance

	Network Monitoring/Surveillance
Description	This strategy uses information collected from a variety of sources including detectors and sensors, operational data feeds from centers, probe data (often from third-party private providers) and eventually connected vehicles to monitor network conditions on a near real-time or real-time basis. The information may be used to determine network performance measures such as speed and travel times, or it may be information collected from the vehicles and processed by the infrastructure, e.g. environmental data and infrastructure conditions monitoring data. Additional data are collected including crash data, road condition data, road closures and other operational decisions to provide context for measured transportation performance and additional safety and mobility-related measures. More complex performance measures may be derived from the collected data The data derived from these sources can be used locally such as when traffic detectors are connected directly to a signal control system or remotely (e.g., when a CCTV system sends data back to the Traffic Management Center). The data generated by this strategy enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect data for traffic strategy development and long range planning. The Institute for Transportation has been active in conducting research that aims to maximize the potential benefits of network monitoring/surveillance systems to initiate timely alerting and to access the performance of the transportation system.
ICM Category	• Foundational strategy
Anticipated Benefits	• Improved safety and emergency response (e.g., incident detection, verification and response) • Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Improved institutional cooperation (e.g., sharing of information between agencies) • Improved customer experience and perception
Provided Functionality	• Enhances roadway situational awareness
Prerequisite Functionality Required	• Communications
Complementary and/or Supported Strategies	• Supports or enhances most ICM strategies outside of system modifications.
Examples	• Widely adopted

Traveler Information Dissemination

	Traveler Information Dissemination
Description	This fundamental strategy provides traveler information using roadway equipment such as dynamic message signs and highway advisory radio and/or commercially available data via mobile devices. A wide range of information can be disseminated including traffic and road conditions, closure and detour information, travel restrictions, incident information, travel time estimate, emergency alerts, and driver advisories. Traveler information can be provided to drivers at specific equipped locations on the road network. Careful placement of the roadway equipment provides the information at points in the network where the drivers have recourse and can tailor their routes to account for the new information.
ICM Category	• Foundational strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Improved institutional cooperation • Improved customer experience and perception
Provided Functionality	• Enhances traveler decision making
Prerequisite Functionality Required	• Communications
Complementary and/or Supported Strategies	• Supports or enhances most ICM strategies outside of system modifications.
Examples	• Widely adopted

TMC Enhancement / Expanded Operations

	TMC Enhancement / Expanded Operations
Description	This strategy expands the resources and operations of Iowa DOT's existing TMC to enhance current operations and coverage (geographic and times of day). It will also enhance institutional relationships through improved monitoring of arterial networks that connect with freeway or state-owned roadways. Expanded functions could include expanding services to include arterials presently not actively monitored so that freeways and arterials can be managed in a more integrated manner.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making (e.g., enhances transportation planning and real-time decision making) • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Improved transportation operations including enhanced traffic monitoring, data collection and information provision along both freeways and connecting arterials.
Prerequisite Functionality Required	• Communications • Traffic data collection and processing • Network monitoring and surveillance • Traveler information dissemination
Complementary and/or Supported Strategies	• This strategy, while focusing on expanding services provided by the TMC will support most ICM strategies (outside of system modifications).
Examples	• City of Austin, TX • Las Vegas, NV

Ramp Terminal Treatments

	Ramp Terminal Treatments
Description	Ramp terminal treatments focus on solving problems at the ramp/arterial intersection, on the freeway (e.g., exit ramp traffic queuing onto the freeway mainline), or on freeway ramps. Treatments include signal timing improvements, ramp widening, additional storage or new turn lanes on arterials, and improved signing, and pavement markings on or adjacent to ramps. These treatments are geared to improving localized problems at either entrance or exit ramp terminals. At exit ramp terminals, the strategies are aimed at reducing queue spillback onto the freeway, but may also be aimed at improved arterial flow by limiting the amount of freeway traffic that can access certain areas in the arterial network. At entrance ramps, treatments can better coordinate timing of ramp signals and arterial traffic signals and/or provide additional storage space on the arterial to prevent ramp queues from extending into the adjacent arterial intersection.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility (e.g., reduced delay, queuing impacts, and upstream arterial impacts) • Increased return on and use of existing investment • Improved institutional cooperation
Provided Functionality	• Improves safety and traffic flow at freeway entrance and exit ramps and their connections to the arterial roadway network.
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Ramp metering • Traffic signal system improvements • Adaptive traffic signal control • Access control
Examples	• University Parkway – adding additional lanes to an off-ramp (Sarasota, FL)

Ramp Closure

	Ramp Closure
Description	Ramp closure involves the closing of an entrance or exit ramp to all traffic, or to specific vehicle classes on a temporary, intermittent, or permanent and is generally considered to improve safety at locations with severe geometric limitations. Ramp closure is an extreme strategy that should only be considered when other ramp treatments are not suitable. Besides locations with severe geometric deficiencies, ramp closure may also be a viable option for managing special event traffic or controlling traffic in or around work zones.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved safety and emergency response (e.g. reduced rear end and sideswipe crashes at problematic freeway entrance ramps) • Improved accessibility and mobility (e.g., improved freeway traffic flow) • Reduced or shifted demand (also improves neighborhood impacts) • Improved institutional cooperation
Provided Functionality	• Improves safety and traffic flow at freeway entrance and exit ramps and their connections to the arterial roadway network.
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Access control
Examples	• Honolulu, HI • I-43 (Milwaukee, WI)

Special Use Ramps

	Special Use Ramps
Description	Special use ramps provide preferential treatment to a specific class or classes of vehicles, and can be applied to either entrance or exit ramps. Special use treatments include exclusive access to ramps for a class of vehicle (e.g., high occupancy vehicle (HOV), emergency, freight, or construction) or special lanes on a ramp for exclusive use by these vehicle classes. Special use treatments are best undertaken in a coordinated effort with other special use treatments and programs. For example, transit management programs may identify candidate ramps where transit vehicle priority considerations may be deployed.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved institutional cooperation • Improved customer experience and perception
Provided Functionality	• Provide preferential treatment to high occupant and/or special classes of vehicles
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Ramp metering • Access control
Examples	• Southern California Association of Governments – truck only ramps • I-710 truck lanes (Los Angeles, CA)

Ramp Metering

	Ramp Metering
Description	Comprised of traffic signals installed on freeway on-ramps to control the frequency at which vehicles enter the flow of traffic on the freeway. Ramp metering reduces overall freeway congestion by managing the amount of traffic entering the freeway and by breaking up platoons that make it difficult to merge onto the freeway. Traditional ramp metering involves the use of pre-timed signals that operate with a constant cycle in accordance with a metering rate prescribed for the control period. Adaptive ramp metering or traffic responsive ramp metering relies on vehicle detection systems to select metering rates. Benefits of effective ramp metering include traffic speed increase, travel time reduction, collision reduction, and emissions reduction.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved safety and emergency response (e.g., reduced speed differentials) • Improved accessibility and mobility (e.g. improved freeway vehicle speeds and throughput) • Reduced or shifted demand • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact
Provided Functionality	• Harmonizes the flow of traffic entering a freeway.
Prerequisite Functionality Required	• Network surveillance
Complementary and/or Supported Strategies	• Ramp terminal treatments
Examples	• Minneapolis, MN • Seattle, WA • Denver, CO • Detroit, MI • Portland, OR • Milwaukee, WI • Chicago, IL

Adaptive Ramp Metering

	Adaptive Ramp Metering
Description	Adaptive ramp metering is like ramp metering but is more sophisticated in its metering approach. Like ramp metering, adaptive ramp metering reduces overall freeway congestion by managing the amount of traffic entering the freeway and by breaking up platoons that make it difficult to merge onto the freeway. However, instead of pre-timed signals adaptive ramp metering or traffic responsive ramp metering relies on vehicle detection systems to select the most appropriate metering rates based on observed traffic. Benefits of effective ramp metering include traffic speed increase, travel time reduction, collision reduction, and emissions reduction.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Reduced or shifted demand • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact
Provided Functionality	• Harmonizes the flow of traffic entering a freeway.
Prerequisite Functionality Required	• Network Surveillance • Traffic signal control/software
Complementary and/or Supported Strategies	• Ramp terminal treatments
Examples	• I-680 (Caltrans) • I-210 (Caltrans) • I-45 (Houston, TX) • Portland, OR • WSDOT • Caltrans District 7 • MnDOT • VDOT • VicRoads

Dynamic Junction Control

	Dynamic Junction Control (DJC)
Description	Junction control is the dynamic provision of lane access based on highway traffic present and merging/diverging traffic to give priority to the facility with higher volume to minimize the impact of the merging/diverging movement. Using signs, mainline lanes can be closed or become an exit, shoulders can be opened, and so forth to accommodate entering or exiting traffic. A strategy variation is dynamic turn restrictions on arterials. DJC is applicable to interchanges and on-/off-ramps. Some potential benefits of DJC include reduced travel time, reduced travel delay, reduced ramp delay, and increased travel speeds.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility (e.g., improved vehicle speeds and reduce delay) • Increased return on and use of existing investment • Reduced environmental impact
Provided Functionality	• Reduces impact of vehicles entering and exiting the freeway at high volume locations.
Prerequisite Functionality Required	• Network surveillance • Traffic information dissemination
Complementary and/or Supported Strategies	• Bus on-shoulder • Dynamic shoulder lanes/part-time shoulder use
Examples	• Dynamic Lanes on SR 110 (Pasadena Freeway, Los Angeles)

Dynamic Shoulder Lanes/Part-time Shoulder Use

	Dynamic Shoulder Lanes/Part-time Shoulder Use
Description	The dynamic opening of a shoulder lane to traffic or dynamic closure of travel lanes on a temporary basis in response to increasing congestion or incidents. This strategy provides additional capacity when it is needed such as during peak travel periods. The temporary addition of a shoulder lane allows congested roadways to have higher throughput—even if the speeds are reduced. Adding an additional lane in the form of temporary shoulder use delays the onset of congestion and breakdown and increases the facility's overall throughput. By increasing capacity and encouraging more uniform speeds, the traffic flows more smoothly and efficiently, which can improve travel time reliability.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility (i.e., vehicle throughput and travel time reliability) • Increased return on and use of existing investment • Reduced environmental impact
Provided Functionality	• Provides temporary increase in roadway capacity.
Prerequisite Functionality Required	• Roadway basic surveillance • Roadway traffic information dissemination
Complementary and/or Supported Strategies	• Traffic incident management • Variable speed limits • Dynamic roadway warning
Examples	• I-66 ATM (Virginia) • I-35W Priced Dynamic Shoulder Lane (Minneapolis, MN) • Seattle, WA

Dynamic Truck Restrictions

	Dynamic Truck Restrictions
Description	This strategy requires all truck traffic to use designated lanes in a dynamic manner during peak periods. The intent is to increase the homogeneity of speed on each lane and to minimize the disruption in traffic flow caused by heavy vehicles. The dynamic nature of the treatment allows for more flexibility in application as opposed to static restrictions. The activation of the signs indicating the presence of restrictions is usually automated and is triggered by real-time traffic volumes. The signs should be placed on overhead gantries for visibility.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility (e.g., traffic flow and speed uniformity) • Reduced or shifted demand • Reduced environmental impact
Provided Functionality	• Reduces truck-related disruptions to traffic flow and safety at specific times of day or problematic locations.
Prerequisite Functionality Required	• Network surveillance • Traffic information dissemination • Connected and automated vehicles
Complementary and/or Supported Strategies	• Weather traffic responsive management • Work zone management
Examples	• Netherlands

7.5.7 Arterial Traffic Management Strategies

ICM Functional Area / Tactic	ICM Category	ICM High-Level Benefits								
		Safety / Response	Mobility / Accessibility	Demand Reduction / Shift	Travel choice / Decision Making	Return on / Use of Existing Investment	Efficiency / Productivity	Institutional Cooperation	Environmental Impact	Customer Experience / DOT Perception
Arterial Management										
Traffic Signal Management	Fundamental		•			•	•	•	•	•
Dynamic Parking Wayfinding	Active and Advanced		•	•	•		•		•	•
Dynamic Parking Reservation	Active and Advanced		•	•	•		•		•	•
Dynamic Priced Parking	Active and Advanced		•	•			•			
Adaptive Traffic Signal Control	Active and Advanced		•			•	•	•	•	•

Traffic Signal Management

	Traffic Signal Management
Description	Traffic signal management involves organizing for the planning, maintenance, design, and operation of signalized intersections and traffic signal systems. Poor traffic signal timing contributes to traffic congestion and delay. Conventional signal systems use pre-programmed, daily signal timing schedules. Periodic manual traffic signal timing improvements or software that can allow operators to perform this activity remotely can improve arterial efficiency especially where there are known changes in traffic volumes or patterns. Improvements to traditional traffic signal timing may include optimizing traffic signal flow for a specific corridor or more broadly a network of corridors.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved accessibility and mobility (e.g., arterial delay) • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Reduces traffic delay along an arterial corridor(s). • Improves traffic flow along an arterial corridor(s).
Prerequisite Functionality Required	• Network surveillance
Complementary and/or Supported Strategies	• Adaptive traffic signal control • Dynamic routing • Transit signal priority • Connected and automated vehicles • Freight operations and freight management improvements • Ramp metering • Adaptive ramp metering • Intersection improvements
Examples	• Utah Traffic Signal Management Plan (Utah DOT) • Operation Green Light (Kansas City, MO) • Regional Traffic Signal Improvement Program (Denver CO) • Fargo-Moorhead Traffic Operation Action Plan (North Dakota) • Traffic Signal Synchronization Program (Los Angeles County, CA)

Dynamic Parking Wayfinding

	Dynamic Parking Wayfinding
Description	This strategy provides real-time parking-related information such as space availability and location to travelers to optimize the use of parking facilities and minimize time spent searching for available parking. Parking availability is continuously monitored and routing information to the parking space can be provided to drivers.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility (e.g., reduced congestion and delay from vehicles searching for available parking) • Reduced or shifted demand • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity (e.g., reduces need and effort to search for available parking) • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Reduces the need to search for available parking and in turn reduces demand near parking venues.
Prerequisite Functionality Required	• Network surveillance (vehicle detection) • Traffic information dissemination
Complementary and/or Supported Strategies	• Planned special event management • Dynamic priced parking • Park and ride lots
Examples	• SFPark (San Francisco, CA) • Express Park (Los Angeles, CA)

Dynamic Parking Reservation

	Dynamic Parking Reservation
Description	This strategy provides travelers the ability to reserve a parking space at a destination facility on demand to ensure availability. Parking availability can be continuously monitored and system users can reserve the parking space ahead of arriving at the parking location.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility (e.g., reduced congestion and delay from vehicles searching for available parking) • Reduced or shifted demand • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity (e.g., balances parking supply with parking demand) • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Reduces the need to search for available parking and in turn reduces demand near parking venues.
Prerequisite Functionality Required	• Network surveillance (vehicle detection) • Personal information devices
Complementary and/or Supported Strategies	• Dynamically priced parking
Examples	• QuickPark (San Diego, CA)

Dynamically Priced Parking

	Dynamically Priced Parking
Description	Dynamically priced parking allows parking rates to be dynamically set as demand for parking increases/decreases. This strategy may be used to reduce parking problems in a specific location or to reduce vehicle traffic in an area. It can also be used to recover parking facility costs, to generate revenue for other purposes (such as a local transportation program or downtown improvement district), or for a combination of these objectives.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility (e.g., encourages use of transit) • Reduced or shifted demand • Improved transportation efficiency and productivity (e.g., balances parking supply with parking demand)
Provided Functionality	• Shifts parking demand to parking lots/garages with excess capacity.
Prerequisite Functionality Required	• Network surveillance (vehicle detection) • Personal information devices
Complementary and/or Supported Strategies	• Ridesharing • Telecommuting • Dynamic parking reservation
Examples	• QuickPark (San Diego, CA) • Carpi (Standford, CA) • ExpressPark (Los Angeles, CA) • Park Smart (New York, NY) • SFpark (San Francisco, CA)

Adaptive Traffic Signal Control

	Adaptive Traffic Signal Control
Description	Adaptive Traffic Signal Control (ATSC) is the continuous monitoring of arterial traffic conditions and queuing at intersections and the dynamic adjustment of signal timing to smooth traffic flow along coordinated routes and to optimize one or more operational objectives (such as minimize overall stops and delays or maximize green bands). Applicable on arterials, this strategy is also known as responsive and/or multimodal preferential signal control.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility (e.g., reduced delay and improved arterial traffic flow) • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Reduces traffic delay along an arterial corridor(s). • Improves traffic flow along an arterial corridor(s).
Prerequisite Functionality Required	• Network surveillance (cameras and detection)
Complementary and/or Supported Strategies	• Ramp terminal treatments • Adaptive ramp metering • Connected and automated vehicles
Examples	• McKnight Road Corridor, Allegheny County, PA • Rhode Island Airport Corporation • Midtown in Motion, New York City, NY • Burleigh Road Corridor, Milwaukee, WI • Multiple arterial corridors adjacent to the Zoo Interchange, Milwaukee, WI

7.5.8 Infrastructure Enhancement Strategies

		ICM High-Level Benefits								
ICM Functional Area / Tactic	**ICM Category**	Safety / Response	Mobility / Accessibility	Demand Reduction / Shift	Travel choice / Decision Making	Return on / Use of Existing Investment	Efficiency / Productivity	Institutional Cooperation	Environmental Impact	Customer Experience / DOT Perception
Infrastructure Enhancement										
Park and Ride Lots	Fundamental		•	•	•				•	•
Acceleration / Deceleration Lanes	System Modification	•	•				•		•	
Access Control	System Modification	•	•	•			•		•	
Bottleneck Removal	System Modification	•	•			•	•		•	•
Freight-Rail Improvements	System Modification	•	•				•	•	•	
Cycle Tracks	Active and Advanced	•	•		•		•		•	•
Crash Investigation Sites	System Modification	•	•				•		•	•
Connected and Automated Vehicles	Emerging	•	•	•	•	•	•		•	•
Smart Cities	Emerging				•	•	•	•	•	•

Park and Ride Lots

	Park and Ride Lots
Description	Park and ride lots are parking facilities located at transit stations, bus stops, and highway on-ramps, particularly at the urban fringe, to facilitate transit and rideshare use. Parking is generally free or significantly less expensive than in urban centers. ITS elements can accompany and be deployed in conjunction with park and ride lots to enhance traveler information needs regarding parking capacity, transit vehicle arrival, and other information that can improve decision making.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Provides additional parking capacity • Improves public transportation accessibility
Prerequisite Functionality Required	• Dependent on complementary strategies implemented. Could include communications to enable en-route and pre-trip traveler information as well as remote monitoring functions.
Complementary and/or Supported Strategies	• Surveillance (cameras, occupancy sensors) • Information dissemination (dynamic/hybrid static and dynamic signs) • Carpooling/vanpooling • Transportation management associations • Connected and automated vehicles
Examples	Widely Implemented, including: • Milwaukee, WI • Chicago, IL • Seattle, WA

Acceleration/Deceleration Lanes

	Acceleration/Deceleration Lanes
Description	Acceleration/deceleration lanes allow drivers to speed up or slow down in a space not used by high-speed through traffic. Incorporating speed change lanes into the roadway design can mitigate speed differences between vehicles and the resulting stop and go behavior that may be associated with this difference. Deceleration lanes allow traffic exiting a major street to slow down to a safer speed to make a left or right turn at an intersection without affecting the main flow of traffic. Dedicated acceleration lanes allow cars that are joining the main road to speed up to match the flow of traffic. The proper use of acceleration/deceleration lanes increases the average speed on freeways and major streets, reduces the delays on ramps, and increases safety by reducing the number of conflicts between slow speed and higher speed vehicles.
ICM Category	• System modification
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility (reduces vehicle speed differentials) • Improved transportation efficiency and productivity • Reduced environmental impact
Provided Functionality	• Reduces speed variations in traffic • Improves traffic flow
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Dynamic speed advisories/limits • Dynamic shoulder lanes/part-time shoulder use • Queue warning
Examples	• Austin, TX • Minneapolis, MN • I-81/I-70 Interchange (Maryland)

Access Control

	Access Control
Description	Access control is a term for a set of techniques that control several elements of a street, such as the spacing, design, and operation of driveways, turns, medians, and intersections. It serves as an effective congestion reduction technique because it controls where vehicles may enter and leave the road. Adequate access management improves safety on roads by limiting the number of locations where cars can slow down or speed up to exit or enter the road. In retrofit situations, public agencies must work with developers in a cooperative process to create the best solution.
ICM Category	• System modification
Anticipated Benefits	• Improved safety and emergency response (e.g., reduced conflict points) • Improved accessibility and mobility (e.g., improved traffic flow) • Reduced or shifted demand • Improved transportation efficiency and productivity • Reduced environmental impact
Provided Functionality	• Reduces potential vehicle conflict points • Improves traffic flow
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Dynamic truck restrictions • Intersection improvements • Planned special event management • Bottleneck removal
Examples	• Colorado Access Control Demonstration Project • Iowa Access Management Research and Awareness Program

Bottleneck Removal

	Bottleneck Removal
Description	Recurring localized bottlenecks are encountered during every day commutes and are characterized as being relatively predictable in cause, location, time of day, and approximate duration. Some are "periodic problems" where volume surges temporarily exceed the roadway capacity. Common locations of bottlenecks include places where the number of lanes decreases, at ramps and interchanges, and where there are roadway alignment changes (sharp curves, steep hills, etc.). Innovative transportation agencies have realized that bottleneck removal is "low hanging fruit"—small projects that can result in big benefits. One or two corrections to inefficient locations may be all that is needed to improve the condition. Some of the typical low-cost solutions include restriping, adding travel lane(s) for a short section by reducing lane widths and converting shoulders, adding lanes to accommodate entering and exiting traffic, and modifying ramps
ICM Category	• System modification
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Reduces chokepoints in traffic flow
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Access control • Intersection improvements
Examples	• Dallas-Fort Worth Metro Area • Minneapolis, MN

Freight-Rail Improvements

	Freight-rail Improvements
Description	Freight rail improvements include strategies that encourage freight to move by rail or that make surface transportation infrastructure more efficient by reducing rail-related impacts. These include freight rail relocation or infrastructure improvements, intermodal transportation centers, rail crossing detection and warning Investment in freight rail relocation/improvements or the construction of new intermodal centers can consolidate freight movement to rail corridors while removing some long-distance truck traffic from congested corridors. Improved train detection can allow railroads and local agencies to coordinate incident management and improve crossing safety.
ICM Category	• System modification
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact
Provided Functionality	• Reduces truck and auto interaction and conflicts
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Traffic signal improvements • Adaptive traffic signals
Examples	• Seattle, WA (At grade rail crossings in the industrial area)

Cycle Tracks

	Cycle Tracks
Description	A cycle track is an exclusive bike facility that combines the user experience of a separated path with the on-street infrastructure of a conventional bike lane. A cycle track is physically separated from motor traffic and distinct from the sidewalk. Cycle tracks have different forms but all share common elements—they provide space that is intended to be exclusively or primarily used for bicycles, and are separated from motor vehicle travel lanes, parking lanes, and sidewalks. In situations where on-street parking is allowed cycle tracks are located to the curb-side of the parking (in contrast to bike lanes).
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Reduces bicycle and vehicle interaction and conflicts
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Bike sharing • Special event management
Examples	• 15th Street, Washington D.C • Vassar Street, Cambridge, MA • 9th Avenue, New York City, NY • Madison, WI

Crash Investigation Sites

	Crash Investigation Sites
Description	Traffic incidents located either on the freeway mainlines or shoulder can greatly reduce the capacity of a roadway. Furthermore, the safety of individuals involved in crashes can be jeopardized when getting out of their vehicles along the mainline. Crash investigation sites are specifically designated and signed to provide a safe area where motorists with partially disabled vehicles, law enforcement, fire and rescue, and other public service vehicles can be temporarily relocated. Generally, these sites are identified by signs and sometimes pavement markings, have sufficient space to park multiple vehicles and lighting to ensure personal safety, and often have access to phone service.
ICM Category	• System modification
Anticipated Benefits	• Improved safety and emergency response (e.g., reduced potential for secondary incidents and reduces responder exposure) • Improved accessibility and mobility (e.g., reduced incident impacts on traffic flow) • Improved transportation efficiency and productivity • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Reduces duration and impact of incidents on traffic flow
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Incident management • Work zone management • Park and ride lots • Ramp configurations
Examples	• I-88 and I-90 (Illinois Tollway) • I-94 (Milwaukee, WI) • I-94 (Michigan)

Connected and Automated Vehicles

	Connected and Automated Vehicles
Description	Automated vehicles are those in which at least some aspect of a safety-critical control function (e.g., steering, throttle, or braking) occurs without direct driver input. Automated vehicles may be autonomous (i.e., use only vehicle sensors) or may be connected (i.e., use communications systems such as connected vehicle technology, in which cars and roadside infrastructure communicate wirelessly). Connected vehicles use communication technology to allow on-board systems to communicate with other vehicles, the roadside infrastructure, or other devices or systems (including the "cloud"). Connected vehicle technology enables a variety of safety and mobility services, such as intersection collision avoidance and enhanced in-vehicle traveler information systems. Connectivity is also an important input to realizing the full potential benefits and broad-scale implementation of automated vehicles. Connected and automated vehicles have the potential to bring about transformative safety, mobility, energy, and environmental benefits to our nation's surface transportation system. These benefits could include crash avoidance, reduced energy consumption and vehicle emissions, reduced travel times, improved travel time reliability and multi-modal connectivity, and improved transportation system efficiency and accessibility, particularly for persons with disabilities and the growing aging population.
ICM Category	• Emerging strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment (e.g., potential for shorter vehicle headways) • Improved transportation efficiency and productivity • Reduced environmental impact (e.g., vehicle platooning and adaptive cruise control) • Improved customer experience and perception • Increased transportation accessibility and efficiency • Improved parking efficiency
Provided Functionality	Dependent on specific CAV application, but could include: • In-vehicle communications and signing • Vehicle control automation • Vehicle safety monitoring • Automated vehicle operations • Vehicle collision warnings
Prerequisite Functionality Required	• Dependent on specific CAV application • Connected vehicle on-board system • Connected vehicle roadside units

	• Communications (Dedicated short range communications or 5G)
Complementary and/or Supported Strategies	• Dependent on specific CAV application
Examples	• Ann Arbor, MI • Columbus, OH • Madison, WI • Tampa, FL • New York City, NY

Smart Cities

	Smart Cities
Description	A system of interconnected systems, including employment, health care, retail/entertainment, public services, residences, energy distribution, and, transportation. This 'system of systems' is tied together by information and communications technologies (ICT) that transmit and process data about all sorts of activities within the city. The goal of the smart city concept is to improve quality of life for the citizens and to improve efficiency of government by using technology to better serve the public. A fundamental aspect vital to the success of a smart city is ICT. The advent of "big data" and improved communications because of smart phone applications and social media have allowed ICT to power smart cities and simultaneously make ICM viable.
ICM Category	• Emerging strategy
Anticipated Benefits	• Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact (e.g., reduced or sustainable energy) • Improved customer experience and perception
Provided Functionality	Dependent on smart cities initiatives implemented, but could include: • Improved efficiency in infrastructure monitoring • Improved data capture, sensing, and processing • Travel information and planning
Prerequisite Functionality Required	• Data management and analytics • Information and communications technologies
Complementary and/or Supported Strategies	Dependent on smart city initiatives, but could include: • Connected and automated vehicles • Network surveillance
Examples	• Smart Columbus (Columbus, OH) • Austin CityUP (Austin, TX) • Kansas City, MO

7.5.9 Traveler Information Strategies

ICM Functional Area / Tactic	ICM Category	ICM High-Level Benefits: Safety / Response	Mobility / Accessibility	Demand Reduction / Shift	Travel choice / Decision Making	Return on / Use of Existing Investment	Efficiency / Productivity	Institutional Cooperation	Environmental Impact	Customer Experience / DOT Perception
Traveler Information										
Comparative Travel Time Messaging	Active and Advanced		•	•	•	•	•	•	•	•
Predictive Traveler Information	Active and Advanced	•	•	•	•	•	•		•	•
Dynamic Speed Advisories / Limits	Active and Advanced	•	•		•				•	•
Queue Warning	Active and Advanced	•	•		•				•	•

Comparative Travel Time Messaging

	Comparative Travel Time Messaging
Description	Comparative travel time messaging provides en-route motorists with dynamic travel times for two or more unique, but comparable, routes to a downstream destination. Based on the travel times displayed, motorists can easily gauge travel and traffic conditions for the signed routes and select in real time the route with the least delay. In 2014 Iowa began providing comparative travel time estimates on dynamic message signs located along I-235. This strategy would expand on this implementation and more specifically provide travel time estimates for arterials that parallel interstate highways. This will allow travelers to select among freeway and arterial routes based on displayed travel times.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Passively shifts demand to networks with available capacity
Prerequisite Functionality Required	• Network surveillance • Traveler Information dissemination
Complementary and/or Supported Strategies	• Dynamic routing • Congestion pricing • Traveler information dissemination • Predictive traveler information
Examples	• Milwaukee, WI (I-94/I-894 Interchange reconstruction)

Predictive Traveler Information

	Predictive Traveler Information
Description	This strategy involves using a combination of real-time and historical transportation data to predict upcoming travel conditions and convey that information to travelers pre-trip and en-route (such as in advance of strategic route choice locations) in an effort to influence travel behavior. Predictive traveler information can be incorporated into a variety of traveler information mechanisms (e.g., multi-modal trip planning systems, 511 systems, dynamic message signs) to allow travelers to make better informed choices.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved transportation efficiency and productivity (e.g., integrates multiple, growing data streams) • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Improves traveler information and decision making
Prerequisite Functionality Required	• Network surveillance • Traffic information dissemination • Machine learning
Complementary and/or Supported Strategies	• Traffic incident management • Weather responsive traffic management • Smart cities • Connected and automated vehicles • Queue warning • Dynamic speed advisories/limits • Dynamic rerouting
Examples	• Las Vegas, NV • Tampa, FL

Dynamic Speed Advisories/Limits

	Dynamic Speed Advisories/Limits
Description	The dynamic change in speed limits or advised speeds based on road, traffic, and weather conditions. Speeds can either be enforceable (regulatory) speed limits or recommended speed advisories, and can be applied to an entire roadway segment or individual lanes. This smoothing process helps minimize the differences between the lowest and highest vehicle speeds. Other terms commonly associated with dynamic speed advisories/limits include variable speed limits and speed harmonization. Some potential benefits include reduced difference between posted speed and actual speed, reduced speed variability, reduced spatial extent of congestion, reduced temporal extent of congestion, reduced crash rates, and reduced crash severity.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Enhanced traveler choice and decision making • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Provides warning of a change in conditions • Smooths traffic flow heading into incidents or adverse conditions.
Prerequisite Functionality Required	• Network surveillance • Traffic information dissemination • Roadway environmental monitoring
Complementary and/or Supported Strategies	• Incident management • Dynamic shoulder lanes/part-time shoulder use • Queue warning • Connected and automated vehicles • Weather responsive traffic management • Work zone management
Examples	• I-95 and I-295 VSL Maine DOT • PA 76 Toll Road VSL (Pennsylvania Turnpike Commission) • I-80 VSL (WYDOT) • Loop 1604 (San Antonio, TX) • WSDOT Smarter Highways

Queue Warning

	Queue Warning
Description	The dynamic display of warning signs to alert drivers that congestion and queues are ahead. Warnings are typically displayed on dynamic message signs and possibly coupled with flashing lights. This strategy is typically applied in specific locations in advance of known congestion points. Some potential benefits of this strategy include reduced rear-end crashes where the warning is in effect, increased travel speeds, and reduced speed differential.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved safety and emergency response • Improved accessibility and mobility • Enhanced traveler choice and decision making • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Provides warning of queues • Smooths traffic flow
Prerequisite Functionality Required	• Network surveillance • Traffic information dissemination
Complementary and/or Supported Strategies	• Predictive traveler information • Dynamic speed advisories/limits • Traffic incident management • Work zone management • Weather responsive traffic management
Examples	• I-35 work zone end-of-queue warning system (Waco, TX) • I-94 ATM system (Minneapolis, MN) • OR-217 ATM system (Oregon)

7.5.10 Travel Demand Management Strategies

ICM Functional Area / Tactic	ICM Category	ICM High-Level Benefits: Safety / Response	Mobility / Accessibility	Demand Reduction / Shift	Travel choice / Decision Making	Return on / Use of Existing Investment	Efficiency / Productivity	Institutional Cooperation	Environmental Impact	Customer Experience / DOT Perception
Travel Demand Management										
Carpooling / Vanpooling	Fundamental		•	•	•		•		•	•
Telecommuting	Fundamental			•	•		•		•	•
Transportation Management Associations	Fundamental		•	•	•		•	•	•	•
Dynamic Routing	Active and Advanced		•	•	•	•	•	•	•	•
Dynamic Ridesharing	Active and Advanced		•	•	•		•		•	•
Flexible Work Hours	Active and Advanced		•	•	•		•		•	•
Bike Sharing	Active and Advanced		•	•	•				•	•
Congestion Pricing	Active and Advanced		•	•	•	•				•
Mobility-as-a-Service	Emerging		•	•	•		•	•		•

Carpooling/Vanpooling

	Carpooling/Vanpooling
Description	Carpooling is probably the most flexible type of alternative commute arrangement. Carpools consist of 2 or more people traveling together in the same vehicle. Carpooling can be very flexible where employees ride together one or more days a week. It is up to the carpool partners to decide who drives and how often. This makes carpooling a viable option for employees who live near one another and have consistent work schedules. Vanpools are a cost-effective way to commute for employees who have consistent work hours. Vanpools are groups of 7 to 15 employees commuting together in one vehicle. Some vanpools serve more than one worksite. An employee drives the van and the passengers share the monthly cost of commuting. Implementing a vanpool program does not require more assistance than a carpool or even transit program. However, the benefits can be great too since one vanpool can reduce parking demand by up to 14 spaces.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand (i.e., peak-period vehicle demand) • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity • Reduced environmental impact
Provided Functionality	• Maximizes roadway capacity potential
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Park and ride lots • Transit incentives
Examples	Many locations including: • DART vanpools, Des Moines, IA • GoTriangle Commuter Program, Triangle Region, NC • Cornell University (Ithaca, NY) • Emory University (Atlanta, GA) • Nike (Beaverton, OR)

Telecommuting

	Telecommuting
Description	Telework/telecommuting is a flexible work arrangement that allows employees to perform officially assigned duties at a location other than the traditional office. This includes the employee's home, a telework center, or a satellite facility owned or leased by the employer, or by another public or private organization. Typically, the employee covered under a telecommuting agreement, with prior approval, works one or two days in the workweek or pay period at an alternative work site away from the main work site. Telecommuting program has the potential to provide significant transportation-related public benefits including the reduction of traffic congestion.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Reduced or shifted demand (i.e., need for travel) • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity • Reduced environmental impact (also system preservation) • Improved customer experience and perception
Provided Functionality	• Eliminates roadway demand
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Transportation management associations • Special event management
Examples	Many locations, including: • Des Moines, IA – several employers • City of San Antonio – Information Services Department • Mobil Oil (Dallas, TX) • Rice University (Houston, TX)

Transportation Management Associations

	Transportation Management Associations
Description	A transportation management association (TMA) is "an organized group applying carefully selected approaches to facilitating the movement of people and goods within an area." Also called transportation management organizations (TMOs) and other names, they vary widely in size, organization, membership, and services offered. TMAs allow businesses to pool their resources to support commuter transportation strategies and can act in an advocacy role with local government on behalf of its membership. TMAs provide a variety of services related to transportation demand management (TDM), usually focused on expanding knowledge of alternatives to commuting in a single occupant vehicle. A TMA was established in the Des Moines Metropolitan Area in 2001 as part of the I-235 reconstruction with the goal of reducing I-235 peak traffic demand by 10 percent. At this time, the TMA was managed by the Downtown Community Alliance. More recently, responsibility for this organization was handed to the Des Moines Area Metropolitan Planning Organization.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Maximizes roadway capacity potential • Eliminates roadway demand
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Carpooling/vanpooling • Telecommuting • Special event management • Parking management
Examples	• Ride-on (San Luis Obispo County, CA) • Go Lloyd (Lloyd District Portland, OR) • Commuter Challenge Program (Puget Sound Region, WA) • Blackberry Creek Regional TMA (Toronto, Canada) • Transportation Management Association of San Francisco • Commuter Connections (Washington D.C.)

Dynamic Routing

	Dynamic Routing
Description	This strategy uses variable destination messaging (e.g., messaging specific to two or more downstream locations) to disseminate information and make better use of roadway capacity by directing motorists to less congested facilities. These messages could be posted on dynamic message signs, and eventually broadcast directly into in-vehicle displays, in advance of major routing decisions. Real-time and anticipated conditions can be used to provide route guidance and distribute the traffic spatially to improve overall system performance.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment (i.e., demand balancing) • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Balances demand among networks and modes that have excess capacity
Prerequisite Functionality Required	• Network surveillance • Traffic information dissemination
Complementary and/or Supported Strategies	• Connected and automated vehicles • Work zone management • Incident management • Traffic signal improvements • Adaptive traffic signal control
Examples	• I-35 (Hillsboro, TX)

Dynamic Ridesharing

	Dynamic Ridesharing
Description	This strategy involves travelers using advanced technologies, such as smart phones and social networks, to arrange a short-notice, one-time, shared ride. This facilitates real-time and dynamic carpooling to reduce the number of auto trips/vehicles trying to use already congested roadways.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Maximizes roadway capacity potential
Prerequisite Functionality Required	• Carpooling/vanpooling
Complementary and/or Supported Strategies	• Park and ride lots • Transit incentives
Examples	• Bellevue Smart Traveler System (Bellevue, WA) • Los Angeles Smart Traveler (Los Angeles, CA) • Caltrans Dynamic Ridesharing Program (Sacramento, CA) • TransAction Network (Riverside County, CA)

Flexible Work Hours

	Flexible Work Hours
Description	Flexible work scheduling can be provided by employers as an incentive to reduce peak-period commutes. It provides more commute options and therefore additional opportunities to steer people toward efficient alternatives to driving alone on busy routes and during peak periods. It encourages people to think about how, where, and when they travel.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Shifts roadway demand to non-peak periods
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Fare strategies • Dynamic ridesharing
Examples	• Widely implemented

Bike Sharing

	Bike Sharing
Description	Bike sharing, and the sharing of other types of non-motorized forms of transportation including scooters, is a type of transportation service that provides these options to use for a daily, monthly, annual, or trip-based fee. Traditionally, bike sharing systems have been station-based meaning that bicycles must be acquired from and returned to self-serve stations—also known as "smart docks." A growing proportion of systems now have "smart bikes" that are outfitted with all the necessary technology built into the bicycle, which can provide greater flexibility by eliminating the need for permanent stations. Potential benefits of bike sharing include the increase in bicycling visibility, promotion of healthy and active living, and easier transit connections.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Reduced environmental impact • Reduce traffic congestion • Increased system interoperability and benefits (first mile and last mile connections) • Increased transportation accessibility and efficiency
Provided Functionality	• Improved accessibility and mobility • Reduced or shifted demand (i.e., promotes non-auto modes of travel) • Enhanced traveler choice and decision making • Reduced environmental impact • Improved customer experience and perception
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Planned special event management • Transit incentives • Mobility as a service • Cycle tracks
Examples	• Divvy (Chicago, IL) • B-Cycle (Denver, CO) • CitiBike (Miami, FL) • Coast Bikes (Tampa, FL) • Indiana Pacers (Indianapolis, IN)

Congestion Pricing

	Congestion Pricing
Description	Congestion pricing is a congestion management strategy that encourages people not to drive in congested areas through financial incentives or pricing. Congestion pricing harnesses the power of the market to reduce traffic congestion. There are four main types of pricing strategies: • Variably priced lanes, involving variable tolls on separated lanes within a highway, such as Express Toll Lanes or High Occupancy Toll (HOT) Lanes • Variable tolls on entire roadways, both on toll roads and bridges, as well as on existing toll-free facilities during rush hours • Cordon charges—either variable or fixed charges to drive within or into an area within a city • Area-wide charges—per-mile charges on all roads within an area that may vary by level of congestion In some situations, it may be appropriate to offer rebates to avoid traveling during times of congestion instead of imposing a toll. The rebates would be offered to those who sign up for the program and who use transit or travel during off-peak periods. While the use of rebates or other incentives is not usually implemented, it represents a positive or less controversial means to shift driver behavior. The intent of this strategy is to maximize the limited amount of transportation infrastructure capacity that exists by encouraging the use of other, high-occupant forms of travel or traveling outside peak periods. In turn this helps to increase person throughput within congested corridors and/or lessens overall demand. In the case of a toll, the amount charged can vary to support specific transportation and congestion reduction goals (e.g., peak-period surcharge or off-peak discount). Congestion pricing can also improve trip reliability and reduce delay.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility (i.e., reduced delay and improved travel time reliability) • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved customer experience and perception
Provided Functionality	• Maximizes roadway capacity potential • Shifts vehicle demand to other modes and times of day
Prerequisite Functionality Required	• Network surveillance • Traveler information dissemination

Complementary and/or Supported Strategies	• Dynamic routing • Traveler information dissemination • Access control • Event Management
Examples	• Portland, OR (I-5 and I-205) • Puget Sound Region, WA • Dallas/Fort Worth, TX • Sand Diego, CA (I-15) • New York City, NY (Manhattan)

Mobility-as-a-Service (MaaS)

	Mobility-as-a-Service (MaaS)
Description	A combination of public and private transportation services within a given regional environment that provides holistic, preferred, and optimal travel solutions, to enable end-to-end journeys paid for by the user as a single charge. Solutions such as integrated single payment for complete journeys, linking multiple mobility accounts under a common single transit account, and use of multi-modal planning tools to determine a journey are all a part of the MaaS model. MaaS is envisioned to provide better information and better connectivity to help cities and organizations face increasing urbanization and demographic shifts while also providing safe, efficient, and functioning transportation that customers expect.
ICM Category	• Emerging strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity • Improved institutional cooperation • Improved customer experience and perception
Provided Functionality	• Provides on-demand transportation options
Prerequisite Functionality Required	• Integrated payment systems
Complementary and/or Supported Strategies	• Transit incentives • Carpooling and vanpooling • Ridesharing • Bike sharing • Connected and automated vehicles
Examples	• Whim (Helsinki, Finland) • Tompkins County, NY (under consideration) • Smart Mobility (Silicon Valley, CA)

7.5.11 Public Transportation Management Strategies

ICM Functional Area / Strategy	ICM Category	ICM High-Level Benefits: Safety / Response	Mobility / Accessibility	Demand Reduction / Shift	Travel choice / Decision Making	Return on / Use of Existing Investment	Efficiency / Productivity	Institutional Cooperation	Environmental Impact	Customer Experience / DOT Perception
Public Transportation Management										
Transit Incentives	Fundamental		•	•	•	•		•	•	•
Transit Lanes	Fundamental		•	•	•	•		•	•	•
Dynamic Transit Capacity Assignment / On Demand Transit	Active and Advanced		•	•	•	•	•		•	•
Fare Strategies	Active and Advanced			•	•	•		•	•	•
Bus on Shoulder	Active and Advanced		•	•	•	•		•	•	•
Bus Rapid Transit	Active and Advanced		•	•	•	•	•	•	•	•
Transfer Connection Protection	Active and Advanced			•	•		•			•
Transit Signal Priority	Active and Advanced		•	•			•	•	•	•
Express Bus Service	System Modification		•	•	•	*	•	*	•	•
Mobility on Demand	Emerging		•	•	•	*	•			•

Transit Incentives

	Transit Incentives
Description	A strategy to balance the effects of traffic congestion by making public transit use more appealing and encouraging its use. These incentives could include discounted tickets for public transit, free bus rides for commuters, or shuttle buses to nearby rail stations.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Increases perception and use of transit
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Transit lanes • Bus on shoulder • Carpooling/vanpooling • Bus rapid transit
Examples	• City of Alexandria, VA (Carlyle Community Council) • City of Arlington, VA • King County, WA

Transit Lanes

	Transit Lanes
Description	Transit lanes are a portion of the street designated by signs and markings for the preferential or exclusive use of transit vehicles, sometimes permitting limited use by other vehicles. On busy urban streets, transit lanes are the building blocks to provide reliable and robust transit service. Continuous running ways yield the greatest benefit to transit operations, and can often be implemented with little impact, or even positive impact, on general traffic flow. Transit lanes are implemented by repurposing general traffic lanes or parking lanes and are usually implemented on streets that also accommodate private motor vehicles in at least one direction.
ICM Category	• Fundamental strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Increases perception and use of transit • Reduces transit impacts on other vehicular traffic
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Bus rapid transit
Examples	• Watertown, MA • Cambridge, MA • Chicago, IL • El Monte Bus Lane (Los Angeles, CA)

Dynamic Transit Capacity Assignment / On-Demand Transit

	Dynamic Transit Capacity Assignment / On-Demand Transit
Description	Dynamic Transit Capacity Assignment involves re-organizing schedules and adjusting assignments of assets (e.g., buses) based on real-time demand and patterns, to cover the most overcrowded sections of network. Real-time and predicted travel conditions can be used to determine the changes needed to the planned transit operations, thereby potentially reducing traffic demand and subsequent delays on roadway facilities. On-Demand Transit involves travelers making real-time trip requests for services with flexible routes and schedules. This allows users to request a specific transit trip based on their individual trip origin/destination and desired departure or arrival time.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Transit center operator and resource assignment
Prerequisite Functionality Required	• Transit vehicle onboard equipment • Transit management and scheduling software
Complementary and/or Supported Strategies	• Planned special event management • Connected and automated vehicles
Examples	• Columbus, OH • Orlando, FL

Fare Strategies

	Fare Strategies
Description	This strategy involves reducing the fare for use of the transit system in a corridor as congestion or delay on that corridor increases. This encourages selection of transit mode to reduce traffic volumes entering the corridor. Fare changes are communicated in real time to the traveling public, through general dissemination channels such as the transit website, as well as personalized messages to subscribers. Real-time and predicted highway congestion levels and/or the utilization levels of the transit system can be used to adjust transit fare in real time to encourage mode shift necessary to meet agency goals and objectives.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Increases perception and use of transit
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Bus rapid transit • Express bus • Carpooling/vanpooling
Examples	• Widely implemented

Bus on Shoulder

	Bus on Shoulder
Description	Bus shoulder lanes are authorized bus-only lanes that run along selected freeways. They are a low-cost solution that fully use the capacity of existing corridors and provide immediate benefits to fixed route buses operated by local transit agencies. Most bus shoulder lanes are on the right shoulder, which allow buses to enter the freeway from the right-side during peak congestion hours and avoid having to weave into either general purpose or HOV traffic. Bus shoulder lanes are not designed to carry a large amount of traffic, and are only used during specific times so buses can maintain a reliable schedule during periods of peak congestion.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Incentivizes transit use over other less efficient modes • Reduces transit delay
Prerequisite Functionality Required	• Network surveillance
Complementary and/or Supported Strategies	• Network surveillance • Traffic information dissemination • Connected and automated vehicles
Examples	• I-66 (Northern, VA) • I-64 (Hampton Roads, VA) • I-55 and I-94 (Chicago, IL)

Bus Rapid Transit

	Bus Rapid Transit
Description	Bus Rapid Transit (BRT) is a high-quality bus-based transit service that delivers fast, comfortable, and cost-effective services at metro-level capacities. It does this through the provision of dedicated lanes, with busways and stations typically aligned to the center of the road, off-board fare collection, and fast and frequent operations. Because BRT contains features like a light rail or metro system, it is much more reliable, convenient, and faster than regular bus services. With the right features, BRT can avoid the causes of delay that typically slow regular bus services, like being stuck in traffic and queuing to pay on board.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Increased return on and use of existing investment • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Increases perception and use of transit • Reduces transit delay
Prerequisite Functionality Required	• Network surveillance • Traffic information dissemination • Transit fare management
Complementary and/or Supported Strategies	• Transit incentives • Connected and automated vehicles
Examples	• East-West BRT (In Design - Milwaukee, WI) • Loop Link (Chicago Transit Authority) • Ashland Avenue BRT (Chicago Transit Authority) • Rapid Bus (Metro Transit, Minneapolis/St. Paul, MN) • IndyGO BRT (Indianapolis, IN)

Transfer Connection Protection

	Transfer Connection Protection
Description	Transfer Connection Protection (TCP) involves the use of vehicle location and information systems and operational policies to address inter-agency transfers and connections. The goal of a regional TCP system is to reduce passenger wait times at inter-agency transfer points, by minimizing the number of missed connections. This can be done by alerting service board dispatch systems to inter-agency connections that are in danger of being missed. Corrective action can then be considered. For passengers, this will mean reduced waiting time, improved security, and less uncertainty. With TCP service boards should see gradual increases in ridership and revenue, as well as improvements in operating efficiency.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Reduced or shifted demand • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity • Improved customer experience and perception
Provided Functionality	• Transit center multi-modal coordination • Transit vehicle on-board performance/schedule monitoring
Prerequisite Functionality Required	• Transit vehicle on-board communications • Transit stop support equipment • Personal information devices
Complementary and/or Supported Strategies	• Bus rapid transit • Connected and automated vehicles
Examples	• Utah Transit Authority

Transit Signal Priority

	Transit Signal Priority (TSP)
Description	Modification of traffic signal timing or phasing when transit vehicles are present either conditionally for late runs or unconditionally for all arriving transit. TSP can be a powerful tool to improve both transit schedule reliability and transit travel time, especially on corridor streets with long signal cycles and distances between signals. In urban contexts, TSP benefits are amplified when implemented alongside other strategies like dedicated transit lanes.
ICM Category	• Active and advanced strategy
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Reduces transit delay • Increases perception and use of transit
Prerequisite Functionality Required	• TMC signal control (central management software) • Transit vehicle signal priority (on-board transit vehicle subsystems)
Complementary and/or Supported Strategies	• Traffic signal timing improvements • Adaptive traffic signal system • Planned special event management • Transfer connection protection • Express bus service
Examples	• Widely implemented

Express Bus Service

	Express Bus Service
Description	Express bus service is a fixed route service that typically picks up passengers from park-and-ride lots in suburban areas. These commuter routes have limited stops, and typically travel non-stop on highways to reach the destination, usually downtown. Express routes tend to be used for longer distance commuter trips, and many services use HOV lanes. Express routes usually offer service during peak operating (commuter) periods with limited or no service during the mid-day. Fares for the service may be comparable to park-and-ride fares—slightly higher than typical local fixed route service.
ICM Category	• System modification
Anticipated Benefits	• Improved accessibility and mobility • Reduced or shifted demand • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity • Improved institutional cooperation • Reduced environmental impact • Improved customer experience and perception
Provided Functionality	• Reduces transit delay • Increases perception and use of transit
Prerequisite Functionality Required	• None
Complementary and/or Supported Strategies	• Fare strategies • Transfer connection protection • Bus on shoulder • Transit signal priority • Bus rapid transit • Traffic signal timing improvements • Park-and-Ride facilities
Examples	• Widely implemented among transit agencies operating within Major US cities

Mobility on Demand (MOD)

	Mobility on Demand (MOD)
Description	MOD allows for the use of on-demand information, real-time data, and predictive analysis to provide travelers with transportation choices that best serve their needs and circumstances. MOD leverages technologies that allow for a traveler-centric approach that provides better mobility options for everyone. The vision of MOD is a multimodal, integrated, automated, accessible, and connected transportation system in which personalized mobility is a key feature.
ICM Category	• Emerging strategy
Anticipated Benefits	• Improved accessibility and mobility (i.e., first/last mile connection) • Reduced or shifted demand • Enhanced traveler choice and decision making • Improved transportation efficiency and productivity • Improved customer experience and perception
Provided Functionality	• Expands mobility options • Reduce reliance on single occupant travel
Prerequisite Functionality Required	• ITS data (varies on desired functionality) • Personal Information Device
Complementary and/or Supported Strategies	• Transit incentives • Carpooling and vanpooling • Ridesharing • Bike sharing • Connected and automated vehicles
Examples	• Bay Area Rapid Transit (BART) Integrated Carpool to Transit Access Program • The Vermont Agency of Transportation (VTrans) Open TripPlanner • Pierce Transit Limited Access Connections • Dallas Area Rapid Transit (DART) First and Last Mile Solution

Appendix C: ICM Strategy Evaluations

Legend:

- Event Management
- Freeway Management
- Arterial Management
- Traveler Information
- System Modification
- Travel Demand Management

- Major Benefit
- Minor Benefit
- Negligible Benefit

$	Lowest Cost
$$	Mid-Level Cost
$$$	Highest Cost

ICM Strategy (Action)	Location	Foundational	Institutional Capability	Suitability w/ Other ICM Strategies	Visibility	Cost
Build Traffic Signal Inventory Data Portal for Metro Area with Improvement Screening						$
Develop Communications / Fiber Inventory						$
Develop Recurring Signal Optimization Program / Dedicated Funding						$
Update Travel Demand Management Multi-Agency MOU + Media Campaign						$

ICM Strategy (Action)	Location	Safety	Mobility	Reliability	Institutional Capability	Suitability w/ Other ICM Strategies	Visibility	Cost
Pre-stage Response Equipment								$
Naming Conventions for System Ramps								$
Incident Bypass Routes Trailblazer Sign Deployment								$
TMC Managed Signal Timings for Incident Bypass Routes								$$
Median Barrier Breaks	I-80 West and East of Northeast mix master							$$
Special Event Traffic Data Feed - 511								$
Permit Over-Sized Trucks for Off-Peak Only								$
Dynamic Shoulder Lanes / Part-time Shoulder Use	SW Mix Master to Merle Hay Road (Left Shoulder Lane)							$$$

Pilot Arterial Travel Times on Corridor (Deploy Bluetooth / Post to 511)	University Avenue							$$
Pilot Arterial Travel Times on Corridor (Deploy Bluetooth / Post to 511)	Grand Avenue							$$
Fund Signal Optimization	Iowa 28 / 63rd Street (I-235 Interchange Area)							$$
Fund Signal Optimization	Oralabor Road (I-35 Interchange Area)							$$
Fund Signal Optimization	Jordan Creek Parkway (I-80 Interchange Area)							$$
Fund Signal Optimization	Hickman Road (I-35 / I-80 Interchange Area)							$$
Fund Signal Optimization	100th Street / Valley West Drive (I-235 to Douglas Street)							$$
Fund Signal Optimization	60th Street / NW 128th Street (I-80 Interchange Area to Hickman Road)							$$
Fund Signal Optimization	University Avenue (Iowa 28 / 63rd Street to MLK Parkway / 19th Street)							$$
Fund Signal Optimization	Grand Avenue (Iowa 28 / 63rd Street to Fleur Drive)							$$

Add US 65 / Iowa 5 Bypass to Travel Time Comparison in DMS Messaging	Through traffic approaching mix masters (e.g. I-35, I-80 when travel time is competitive0							$
Add US 65 / Iowa 5 Bypass Travel Time Comparison to Truck Information System	Through traffic approaching mix masters (e.g. I-35, I-80 when travel time is competitive0							$
Automated DMS Messaging Based on Queue Detection								$
Extend Acceleration / Deceleration Lanes	I-80 West of SW Mix Master							$$$
Extend Acceleration / Deceleration Lanes	I-35 / I-80 WB from NE Mix Master to NW 2nd Street							$$$
Extend Acceleration / Deceleration Lanes	Highway 65 to NE Mix Master (EB/WB)							$$$
Extend Acceleration / Deceleration Lanes	Merle Hay Road On-Ramps to I-35 / I-80							$$$
Queue Spillback Mitigation	WB I-235: Iowa 28 / 63rd Street Off-Ramp							$$
Add Exit Option Lanes	EB I-235 at Iowa 28 / 63rd Street Off-Ramp							$$$
Add Exit Option Lanes	EB I-235 at Valley West Drive Off-Ramp							$$$